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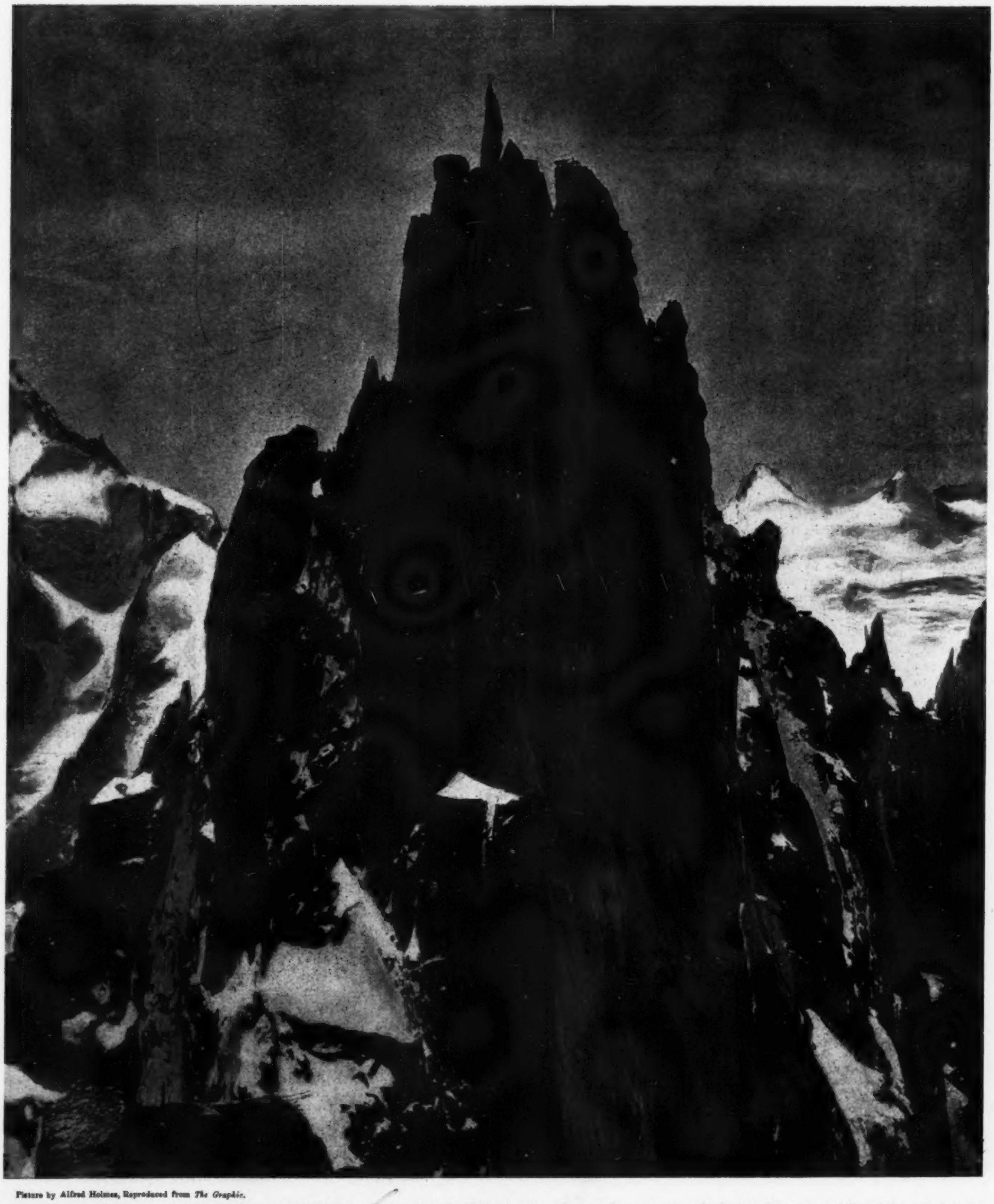


Picture by Alfred Holmes, Reproduced from *The Graphic.*

The Aiguille de Grépon is one of the most difficult and sensational climbs in the Alps, and was among the last to be conquered, defying all attacks until 1881, when Mr. A. F. Mummery, with Alexander Burgener and Benedict Venitz, succeeded in reaching the top. The height of the peak is 11,444 feet.

A RAMPART OF NATIONS—HOW THE ALPS ROSE FROM THE SEA.—[See page 316]

Unscientific Food Tests*

The Fallacy of Testing Food Materials by Animal Inoculation

By W. T. Sedgwick, Sc.D., Professor of Biology and Public Health in the Massachusetts Institute of Technology, Boston

Some years ago it was seriously proposed to test the purity and salubrity of drinking-water by means of animal inoculation. Portions of the water to be examined were cultivated in sterilized bouillon at the body temperature, and the resulting cultures after a stated time were inoculated into guinea-pigs, rats or other test animals. If these sickened or died the water was condemned. Fortunately, since some sense of humor still remained among sanitarians, a proposition so absurd was soon laughed out of court. From time to time, however, this discredited "test" is again gravely brought forward even for water, but more often nowadays for some other form of food or drink, such as eggs, oysters, ice cream, gelatin, catchup, etc. One of the latest examples—but probably not the last—of such proposed employment of it is for frozen eggs, attacked originally because of alleged "decomposition" as indicated chiefly by richness in bacteria and the presence of numerous *Bacilli coli*, but afterward by inference as dangerous to health because sometimes fatal to animals on inoculation.

The frozen eggs involved in a recent case with which I happened to be connected were entirely sweet and agreeable in taste and odor when thawed. Similar eggs had been used for many years and in large quantities by bakers in pies, cakes, custards, etc., not only without perceptible injury or complaint of any kind, but with the greatest convenience, economy and satisfaction. *Disregarding these results of long-continued experience, it remained for certain Government bacteriologists and physicians to discover that such eggs were really "decomposed" and dangerous to health, first, because of the large numbers of bacteria which they contained; second, because of the presence among these of some streptococci and many B. Coli;* third, because when the raw melted egg was inoculated into test animals some of these died; and, fourth, because after the death of such animals certain supposedly objectionable bacteria, *B. enteritidis*, *B. pyocyaneus*, *B. alcaligenes*, etc., were in some instances found in the blood. In other words, over against the long experience of the trade and of consumers of the eggs yielding wholly favorable results of innumerable feeding experiments on human beings, it is now proposed to set up a scanty experimentation on animals; and that not by feeding them as man is fed, and not after cooking of the food materials in question, such as mankind employs, by which process most of the microbes present are destroyed, but by direct injection of large amounts of the raw and uncooked egg substance subcutaneously or into the delicate peritoneal cavity of certain lower animals. To the best of my knowledge and belief, the eggs which it is thus sought to condemn were good and wholesome food, eaten raw or cooked.

It is time to protest against "tests" of this sort which are obviously both irrelevant and misleading, for conclusions based on facts of one order cannot properly be applied to problems of a different order. To realize how unscientific and absurd is the proposal under consideration it is only necessary to recall some simple elementary facts and details.

The body of the higher animals, as every one knows, is not a solid mass completely inclosed by the skin, but a semisolid bundle of tissues tunnelled by a long and folded tube, the alimentary canal or food-tube. This tube possesses its own special walls, expressly adapted for preventing raw food and other foreign substances from entering the real body—which lies between the food-tube and the skin—until such substances have been digested and made ready for absorption. Within this tube, food whether raw or cooked, is chemically treated until some of its components—but only some—are admitted into the body proper, the remainder being held in the tube, moved onward and eventually cast out. This fundamental process of preparation or digestion, normally absolutely inevitable, and carefully and even elaborately conducted, is in subcutaneous or intraperitoneal inoculation entirely omitted, so that the latter procedure is in no wise comparable with the former. Hence, the results, also, of the one process bear no natural or necessary relation to those of the other. As for the preparatory process of cooking, everyone knows that this not only ordinarily causes profound chemical and physical changes, but also destroys most microbes and many toxic organic substances; so that here again the thrusting of raw foodstuffs into the real body becomes a crude and severe procedure, a kind of rough surgical interference, totally different from the normal taking of the same materials into the body by way of the food-tube—perhaps already cooked.

In order to see just where we stand in this matter, we have only to compare the effects of substances of various kinds when taken by the mouth with those of the same substances injected into the real body hypodermically or intraperitoneally. We shall naturally think first of drugs, since it is in the use and abuse of these that resort is oftenest had to direct inoculation. We shall begin, perhaps, with morphin, remembering the familiar fact that a quantity of this drug, which taken hypodermically would quickly kill, can be taken with impunity by the mouth. The same thing is true in a general way of most drugs and poisons, the arrow-head poison (curare) of the South American Indians, for example, being often without marked effect when eaten, but highly poisonous when inoculated into the real body. Most alkaloids, and the toxins of diphtheria, tetanus, typhoid and other infections act either comparatively feebly or not at all when taken by the mouth, but with comparative severity by direct inoculation.

Passing from drugs, alkaloids and metals to beverages, we recall how different is the effect of brandy and other alcoholic drinks when taken through the mouth and when the same quantity is injected subcutaneously. Again, the germs of two of the worst diseases that afflict the human race, namely, lockjaw and anthrax, while extremely dangerous on inoculation, are comparatively innocuous if taken through the mouth.

As for any bad effects on health of the ordinary foodstuffs used from time immemorial by mankind, very little was heard until about 1890, and a careful investigation will show that the evidence of such bad effects accumulated since that time is mostly inconclusive and unsatisfactory. It seems likely that the evolution in the human race of the habit of discriminating among raw foods, and of using chiefly particular materials, such as certain meats, fish, eggs, fruits, nuts, etc., while avoiding others, has arisen as the result of long and hard experience—experience being only another name for long-continued individual or racial experimenting.

Panum (1856), Selmi (1878) and afterward Brieger (1890) appear to be chiefly responsible for the popular belief that "ptomains" are common in spoiled foods, but both investigation and experience since their day have weakened rather than strengthened the idea of dangers of such poisoning. In point of fact, the whole subject of ptomain poisoning and of food poisoning in general stands to-day in great need of re-examination, and until the results of this are forthcoming we are justified in speaking and writing of either with the utmost reserve. When, remembering the enormous quantities of partially decomposed meats, eggs, fish, shell-fish, milk, fruits and vegetables eaten every day either raw, cooked, or half cooked, not only without apparent injury, but with positive relish and advantage, we think at the same time of the infrequency of cases of ptomain poisoning proved or even alleged—when, for example, we think of the immense amounts of fermented or partially decomposed milk, buttermilk, ice cream, meat, fish, game, cheese, sauerkraut, and the like, constantly consumed without inconvenience of any kind and with positive benefit, it is easy to see how extremely rare must be the occurrence of harmful substances in harmful quantities, at least during the earlier stages of decomposition or decay of ordinary food materials.

Returning now to the proper testing of the purity or salubrity of food materials, it is an old and true saying that the proof of the pudding "is in the eating"—not in its inoculation into animals. This latter test is irrelevant because unnatural, and hence for determining the purity or healthfulness of food materials absolutely worthless. If it may be used for one food substance it may be used for all, and the absurdity is obvious of seeking to determine the suitability of meats, eggs, milk, fish, etc., for human food by trying them on animals, and that not by feeding but by inoculation. Even that popular test in which we are advised to "try it on a dog" does not contemplate surgical inoculation, but only the ordinary process of feeding by the mouth.

Thus far I have entered no protest against the testing of food materials on the lower animals rather than on human beings, but as a matter of fact such experiments are only allowable when for some good reason they cannot be made—as in the case of eggs and other common foodstuffs they easily can be made—on human beings. Moreover, because of the wide differences between man and the lower animals any results of such experiments on the latter can be accepted for human beings, if at all, only tentatively and with much reserve. It is a significant fact that the lower animals do not appear to be susceptible to typhoid fever, either by inoculation or by feeding. Conversely, none of the disease to which hens are susceptible appear to be transmissible to man.

What then, if any, we may ask, is the true significance of results obtained by the testing of food materials by the inoculation of animals? The answer is that if the animal survives and suffers no apparent inconvenience, it must be because no microbes or other substances were injected capable of doing that particular animal harm when taken in that dangerous fashion. This does not prove, however, that if the substance were taken through the mouth, no harm would have come, though it makes such a result unlikely, for the reason that the inoculation test is as a rule far more severe than the feeding test. If, on the other hand, test animals are regularly sickened or killed by such inoculation, then the meaning must be that microbes or other substances were injected which were harmful to those animals when administered in this way. But such a result does not prove the unfitness of the material tested for use as food, since the processes of cooking (a kind of external or artificial digestion) and of ordinary (internal or natural) digestion, absorption, circulation and cellular metabolism, may suffice to change it so extensively and to deliver it to the protoplasms of the body so transformed as to make of it, when taken by them in the ordinary way and at their own convenience, a totally different thing from the same material thrust on them in its raw state and whether they want it or not. In short, the mere sickening or death of animals inoculated with raw food materials throws no light whatever on the purity or healthfulness for food of the material injected. Moreover, the finding of this or that microbe in the body of animals after such inoculation neither proves that the microbe came from the food material injected, nor that, if it did so come, it would have survived the processes of cooking, digestion, absorption, etc., to some or all of which it would have been subjected if the material had been administered by feeding instead of inoculation. Finally, there is no proof that, if it had so survived, it would when administered by the mouth have done any harm.

* Reproduced from the *Journal* of the American Medical Association.

Influence of the Sun's Rays on the Propagation of Hertzian Waves

E. Rothe, taking advantage of the eclipse of the sun on April 17th, investigated the variation in intensity of signals as compared with those ordinarily received. To this end experiments were carried out from the Eiffel Tower on March 4th, 11th, 18th, and 25th, and April 1st, in order to discover the best means for making the necessary measurements. On April 4th signals were transmitted every two hours between 6 A. M. and midnight, the strength of signals being measured at Nancy on a thermo-galvanometer. The results are given below:

6 A. M.	8	10	12 noon	2 P. M.
Thick haze	Hazy			
38 mm.	36	41	45	48
4 P. M.	6	8	10	12 midnight
44	44	—	62	60

On the 15th, 16th, and 18th, at 10:40 A. M., the galvanometer readings were constant at 35 and 36 millimeters, as also on the day of the eclipse at the same hour. On April 17th the sky was blue during the whole of the eclipse. A single cloud formed in front of the sun between 11:20 and 11:25. Simultaneously with the measurement of the intensity of signals the variations in temperature, pressure, intensity of light, velocity of wind, etc., were observed. The results are embodied in curves in the original; these show a correlation between the eclipse, the fall in temperature, the wind velocity, and the intensity of signals. The author speculates whether the augmentation in the strength of the signals is to be attributed to solar radiation or atmospheric variations, and suggests a comparison of results obtained at various stations.—*Science Abstracts.*

Food Preservatives, and the Sodium Benzoate Question*

By J. H. Long

In the last few years the question of the use of "preservatives" in foods has been actively discussed in the general press and also in a number of medical journals. For a time the term preservative was used without qualification, but now, apparently to make a disparaging comparison, we hear of "chemical preservatives" as distinguished from "natural preservatives," and notice, also, an attempt to foster the notion that the bodies of the first group are wholly bad, while those of the second group are good, or, at any rate, allowable in foods.

The public has come to look upon "preservatives" with distrust, if not with fear, since most of the discussion has been waged by those who, for one reason or another, *appear* to be opposed to their use. It is my intention to present some facts bearing on the case.

Our ordinary foods consist of proteins, carbohydrates or fats, or mixtures of these compounds, and some of them are prone to spontaneous decay or decomposition, especially in moist condition. The term "spontaneous" is used here to include the action of natural agents, whether organisms or enzymes. An apple or a potato rots, milk turns sour, a piece of meat putrefies, and the time required for this depends largely on the conditions under which the substances are kept. At a sufficiently low temperature *apparent* changes are not rapid, and many articles of food may be held in good condition by *cold storage* through a long period. But even there certain so-called autolytic changes take place.

Cooking arrests decay in all cases, as a high temperature is destructive of the ferments or organisms on which decay depends, and fortunately most of our foods are prepared from the fresh or natural condition by aid of heat and are served on the table without great delay. But, on the other hand, there are some foods which are not cooked, or if cooked, are not used at once. It is a question what to do in such cases. To illustrate, let us consider the apple. In the natural condition it is pretty well protected by the skin which prevents the action of ferments from the outside; but even so it spoils in time. If the apple is pared and is cut into pieces certain fermentation changes begin very speedily, under ordinary conditions. If these pieces are cooked into a sauce this will keep for a time, but some fermentation will later appear. To go a step further, if the sauce in the hot condition is put into a can, and this is hermetically sealed while at a high temperature the contents will keep a long time, perhaps indefinitely, and this whether the sauce has been sweetened or not. The canning of fruit depends on this principle. When, however, the can is opened the contents must be used very soon, except in the case where a large excess of sugar had been added in the process.

But there are cases where it is not desirable to use the whole of the can at once and where great sweetening is objectionable. It may be desirable to use the sauce as a so-called apple butter, consuming it through days or weeks, rather than at one meal. This is a very natural consideration and the question is how may this end be secured. What is known as apple butter is commonly made by boiling down apples in sweet cider. A mass is secured in this way which is richer than ordinary apple sauce in extractives, and poorer in cellulose. But it is an ideal material for ferment changes, and will not "keep" without some addition. The simplest thing to add to prevent fermentation is an excess of cane sugar, but the very great sweetness which results is to many an objection and the custom therefore prevails of using in place of part of the sugar a considerable amount of spice, generally cloves and cinnamon. This is in every way legitimate, but it must not be forgotten that in using these substances we are adding *preservatives*, as it is mainly for this purpose, and not alone for flavor, that they are needed in the case in point. There is no possible objection to the use of spices for this purpose, but would the same be true if the active principles on which the value of the spices depends were employed instead? The bulk of the spice is cellulose or related material, and absolutely inert as far as preserving or flavoring action is concerned, but with the cellulose there are certain essential oils present which are the valuable and active constituents. In the clove we have, for example, eugenol, and in the cinnamon cinnamic aldehyde, with other compounds in smaller quantity. These active principles are called "natural" substances, but are they not "chemicals" at the same time? They certainly are, and further, they may be made by laboratory methods from substances foreign to the spices and with the same properties found in the spice extractives. If there is no objection to the spice products why should there be to the same active principles made in an artificial way?

Indeed there should be no objection, yet there are thousands of well-meaning people who object to the products of the chemical laboratory which take the place of the less pure and often more expensive products of what they style "nature's" laboratory. These are the people who maintain that the vanillin, the salicylic acid, the benzoic acid and aldehyde of the laboratory are different from and, of course, inferior to the products, "natural" products they call them, from the bean, the oil of wintergreen, willow bark, gum benzoin or the bitter almond. And they are the same people who still object to the wholesomeness of glucose as a food product because it is made in a laboratory way from starch. And there are some physicians in this list. How many of them can tell why they object?

As intimated above, there is little objection to the use of spices on account of physiological action, but when used in amount sufficient to behave as preservatives there may be some objection on the ground of excess of flavor. Many fruits and vegetables have a flavor of their own which it is desirable to conserve, but this may be lost or covered up if in the preparation for the table enough spice is employed to act as a real preservative. By the aid of spicing, pumpkin has been made to take the place of more expensive raw materials in certain canned and bottled condiments, and in the same way other sophistications are made possible. Food manufacturers have, therefore, sought to replace the highly flavored spices by other substances of the same physiological behavior, but which have much less taste or odor. At first sight this would appear to be a perfectly proper course, but, strange to say, a very considerable opposition has arisen in the carrying out of the idea. Any one who is familiar with the advances of modern synthetic organic chemistry must be able to recognize that there should be no inherent difficulty in thus replacing the active principles of the aromatics with compounds no more harmful than they are, but without marked taste or odor. It must be admitted, of course, that such replacing compounds will have *some* physiological action; without this they would have no value, and without the same action the spices would have little value, or no value in some cases. It is a well-known fact that the spices themselves, in large doses, might prove highly injurious, but practically we are not concerned with such large doses, and for the same reason we are not concerned with the large doses of artificial substances which may come into use as preservatives.

Sodium benzoate is one of the compounds introduced by manufacturers in the preparation of a number of condimental foods, but its use has been met by a storm of protest on the part of certain food officials which is almost without precedent. The Bureau of Chemistry of the Department of Agriculture issued a bulletin on the subject in which the results of experiments on a so-called poison squad were detailed, and in which the conclusion was reached that the benzoate is a very dangerous substance and liable to produce a long train of ills in the person using it with food. To many people this conclusion seemed so far removed from anything probably true that numerous protests were soon lodged with President Roosevelt and Secretary Wilson against the findings in this bulletin as well as against the findings of others from the same bureau. These protests were so vigorous and repeated so often by men of good standing, that the President finally decided to appoint a commission to reinvestigate the whole question thoroughly. Accordingly, at the President's request, Secretary Wilson appointed the Referee Board of Consulting Scientific Experts to study certain phases of this question, and especially to determine whether or not sodium benzoate and certain other "chemicals" are in reality injurious to health in the manner in which they are employed in the preparation of foods. As a member of this so-called Referee Board, of which President Remsen of Johns Hopkins University is chairman, I have had occasion to carry out some lengthy experiments on the benzoate question, and with my colleagues have reached conclusions differing decidedly from those advanced by the Bureau of Chemistry. Our conclusions have been published in Report No. 88 of the United States Department of Agriculture.

It is not my intention to discuss the details of that report, as it is readily accessible, but it is proper to state that a considerable mass of evidence is presented to show that sodium benzoate is a comparatively mild substance, which when used in the relatively small quantities called for in catsups and similar articles must be quite harmless. In the Northwestern laboratories a squad of six men was under observation through a period of four months on a diet far richer in benzoate than they could find in any of the foods on the market which the consumer would be likely to reach. In these squad experiments and through subsequent studies I have become thoroughly convinced of the relative harmlessness of the benzoate as used in the condimental foods. That is, I believe it is far less harmful than are the other acid and aromatic bodies used for the same purposes. The experimental work of our board was painstaking and was carried out through a period long enough to satisfy any reasonable demand. The peculiar conditions described in the "poison squad" bulletin of the Bureau of Chemistry were not observed by us, and I believe under proper methods of experimentation they should not be in any case. Our men were not fed with capsules, they were not told that they were eating poison, or that they were engaged on a very dangerous experiment. The "poison squad" notion was not kept constantly before them through newspaper interviews. I am willing to believe that with the probable psychic disturbances from the causes suggested always present, our men, also, might have become ill occasionally, perhaps frequently. The psychic factor is very important in such work, and I am inclined to think that it may have played a very prominent part in the Bureau of Chemistry results.

I do not care to be made to appear as an apologist or champion for sodium benzoate; personally I do not care whether manufacturers use it or not, but I do object, and strongly, to the false statements made concerning its behavior and to the unscientific experiments which have been cited to show its danger. Some of our people seem to be losing their heads over a very simple matter; they seem to forget to use that physiological good sense which my colleague, Dr. Chittenden, reminds us is essential in all such discussions. Chemically sodium benzoate is a mild substance and in its ultimate behavior and fate not unlike the aromatic principles of cinnamon and cloves. Indeed, cinnamic aldehyde seems to follow exactly the same course in metabolism, and both are doubtless much weaker physiologically than is the eugenol of cloves.

As industry advances we shall hear a great deal of *artificial* substances as foods or in foods. The objection to them on this ground is certainly fallacious and undoubtedly will have to be abandoned. It is quite within reason to believe that many foods will be made synthetically; the air contains the elements of our natural foods in unlimited quantities and there are those who believe that the time is not far distant when, to feed the race, the synthesis of compounds from the air must be materially hastened. Recall for a moment the great strides already made in the synthesis of the proteins, and in the condensation of atmospheric nitrogen. These are questions in which the physician is naturally interested and on which he should be enlightened. But, unfortunately, the problems involved are somewhat intricate, and advantage has been taken of this fact to excite the fears of some of our medical men and lead them to make statements and pass resolutions on the matter of "preservatives," and especially on the question of benzoate, for which there is no scientific justification. To say the least, these resolutions are hasty and ill-timed, and not warranted by any situation which obtains. A great deal has been said about the activity of the "interests" in favoring sodium benzoate. It should be apparent to any one who can read that other, and certainly much noisier "interests," are violently fighting it. Medical men should not be fooled by the situation, or influenced by the silly assertion that the members of the Referee Board are prejudiced, or that they are working in favor of any interest except that of the scientific truth. Constant misrepresentation of our aims, or of the attitude of the Secretary of Agriculture in appointing the board, will not accomplish much in the long run.

Along with many other things which are described as artificial it is likely that some preservatives of chemical origin may find a legitimate place in the commercial preparation of certain foods. It is also possible that proper uses may be abused in some cases. Such situations arise even with the common foods, and the right course for the food official is investigation and regulation, rather than wholesale prohibition. Except for the rich, factory-made foods will become the rule, and progress there as elsewhere must be encouraged.

* Reproduced from the *Quarterly Bulletin* of Northwestern University Medical School.

Solar and Lunar Halos

A Description of Principal Varieties Known to Science

By C. Fitzhugh Talman

In all ages certain relatively uncommon phenomena belonging to the class known generically as halos have appealed strongly to the imagination of mankind, and in ancient and mediæval chronicles these interesting meteors figure conspicuously as "signs in the heavens," betokening crises in human affairs. Science has stripped the records of such phenomena of their fantastic embroidery. We know, for instance, that Constantine probably *did* see a luminous cross in the sky; but his, or the chronicler's imagination supplied the *In hoc signo vinces*. Shakespeare tells us that five moons were seen in the sky at one time, following the death of Prince Arthur. Read "four mock-moons in addition to the real moon" and you have, in all probability, a record of sober fact.

What is a halo? Aristotle, who introduced this term into science, applied it generally to rings of light around the sun and moon, but he recognized a sharp distinction between the halo and the rainbow.

The terminology of atmospheric optics is still somewhat confused, but, in its latest developments, is based upon the physical nature of the phenomena concerned, as well as upon their appearance. Defined with regard to appearance only, the forms of the halo are so many and diverse that it is easier to state which optical phenomena of the atmosphere do not belong to this class than which do.

OPTICAL PHENOMENA THAT ARE NOT HALOS.

Watch the moon sailing behind a thin layer of fleecy clouds, and you will see around it a luminous ring, showing spectral colors. Brownish red usually predominates. Bearing in mind that the diameter of the moon is half a degree of a celestial great circle, estimate the radius of the red ring. It will be found to be a few degrees—from one to five, generally. Sometimes, especially when the clouds are lofty and feathery (consisting of ice needles rather than droplets of water) the ring may consist of several series of prismatic colors; outside the brownish-red band of the inner circle (technically called the *aureole*) the colors run in the order violet, indigo, etc., to red; and as often as they may be repeated preserve this order—violet inside, red outside. Under such circumstances the whole may have a radius of ten or fifteen degrees, or even more. The same colored bands may be seen around the sun, when viewed through smoked glass or in a black mirror. This phenomenon is not a halo, but a *corona*, and is due to the diffraction of light by water drops or ice particles or occasionally by dust.

Sometimes, especially on a mountain summit, an observer having his back to the sun, will see his shadow cast upon a bank of fog, and around the shadow of his head will see a circle of prismatic colors, altogether similar to the *corona*. This phenomenon, also, does not belong to the halo family. It is called a *glory*, and like the corona is due to diffraction.

Likewise the rainbow—which is the result of the refraction and reflection of light by drops of water—is quite distinct from every kind of halo; though the term "white rainbow" is sometimes inappropriately applied to the colorless halo of Bouguer, seen on a bank of fog opposite the sun.

Occasionally iridescent patches are seen on the upper clouds at a great distance from the sun or moon, and evidently not forming parts of a corona. This is the phenomenon known as "irisation," and is not a form of halo.

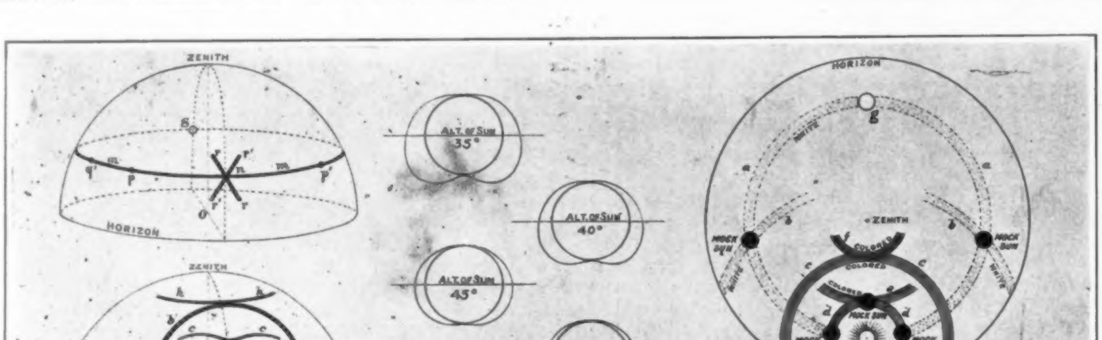


Fig. 1. The Danzig phenomenon, as drawn by Hevelius. The most famous of the complicated halos. Fig. 2. The Petersburg phenomenon, as drawn by Lowitz. Fig. 3. Diagrammatic representation of the Danzig phenomenon. Fig. 4 (after Besson). Upper diagram shows what is seen in the sky opposite the sun; the lower diagram the phenomena that surround the sun itself. Fig. 5. The circumscribed halo and the halo of 22° at various altitudes of the sun (after Pernter). Fig. 6. Solar (or lunar) cross fragments of the halo of 22°, and parhelia, with "tails."

Diagrams of Halo Phenomena.

WHAT CONSTITUTES A HALO.

In a narrow sense the term *halo* is applied to a ring of light seen around a luminous source, as the sun or moon, due to the refraction of light-rays by ice-crystals in the atmosphere; e. g., those forming cirrus clouds. These rings have certain definite radii, determined by the typical forms of the crystals, which are, in general, hexagonal prisms, and by the refractive index of ice. The commonest halo has a radius of about 22 degrees (of a celestial great circle), measured from its brightest part to the luminous source. Outside of this there may be another halo of about 46 degrees radius; and, in rare instances, a halo of 90 degrees radius has been observed. The definite angular size of the halo is one point of difference between the halo and the corona; another is the order in which the spectral colors occur, when visible; from the inner to the outer side of the ring; the order is red, orange, etc., to violet, i. e., just the reverse of the order seen in the corona. However, as halos are often nearly or quite colorless, this criterion frequently cannot be applied.

In a broader sense, the term *halo phenomena* is applied to all luminous appearances in the atmosphere that are due to the refraction or reflection of light (or both) by crystals of ice; including the rings of various radii, tangent arcs, the parhelic circle, parhelia, the anthelion, paranthelia, light-pillars, solar and lunar crosses, etc. The ability to distinguish these apparently heterogeneous phenomena from other optical meteors depends upon familiarity with all the typical forms that have been described by the investigators of this somewhat neglected branch of optics. Concerning these typical forms, except the most common of them, such as the ordinary heliocentric halos and the parhelia, there is a dearth of information in English and American reference-books. The purpose of the present article is to supply this deficiency in the literature available to persons who do not read French and German, so far as this can be done within the limits of a very brief paper. Among the foreign works dealing with this subject in detail, the following are probably the most useful: Bravais, "Mémoire sur les halos" (1847); Grunert "Beiträge sur meteorologischen Optik" (1848); Mascart, "Traité d'optique," tome 3 (1893); Pernter and Exner, "Meteorologische Optik" (1902-1910); Besson, "Sur la théorie des halos" (1909).[1]

The limit of space forbids any attempt to explain the physical processes involved in the production of halos. Suffice it to say that each phenomenon of this class is due to a definite distribution and orientation of the ice crystals, which deflect the light according to well-known optical laws. There are, however, several unsettled questions as to the production of certain forms of halo, for the discussion of which the readers is referred to the works cited in the preceding paragraph.

FORMS OF HALO PHENOMENA.

The commonest halo is the circle of 22 degrees radius. Somewhat less common is the *parhelion* (popularly called a "sun-dog" or "mock-sun"), a disk of light, often brilliantly colored, seen at some distance from the true sun. A similar image of the moon is

[1] Since the present article was written there has appeared in the French journal *L'Astronomie*, a very complete descriptive account of all known forms of halo, "Les différentes formes de halos et leur observation," from the pen of L. Besson, of the Observatory of Montsouris. Any one who wishes to undertake a systematic observation of halos will find M. Besson's memoir an invaluable guide.

called a *paraselene* ("moon-dog" or "mock-moon"). The halo of 46 degrees, some of the forms of *tangent arc*, the *parhelic circle*, and the *light-column* (all described below) are fairly common. All the other forms of halo are rare, while a number have been recorded only once or twice in the history of science. There are several theoretically possible forms of halo that have *never* been observed, so far as known, and anyone who takes up the observation of halos as a hobby, even though he have no scientific training, stands a fair chance of discovering a phenomenon that is quite new to science.

Of the recorded observations of halos, there are three that combine a particularly large number of the various possible forms, and the descriptions of them have become scientific classics. These are known, respectively, as the *Roman phenomenon*, observed by Scheiner in 1630, and drawn by Huyghens; the *Danzig phenomenon*, seen by Hevelius in 1661 (Fig. I); and the *Petersburg phenomenon* (the most complex halo ever reported), seen by Lowitz, at St. Petersburg, in 1790 (Fig. II.)

Of these three the Danzig phenomenon offers the most useful illustration of what may be considered the normal forms of the halo, and the representation of it has therefore been reproduced again and again in scientific books, either as originally drawn, or in the diagrammatic form shown in Fig. III; where *a, a*, indicate the parhelic circle; *b, b*, parts of the halo of 90 degrees, also called the halo of Hevelius; *c, c*, halo of 46 degrees; *d, d*, halo of 22 degrees (the commonest of all halos); *e*, upper tangent arc of the halo of 22 degrees; *f*, upper tangent arc of the halo of 46 degrees, also called the circumzenithal arc (one of the most beautiful of halo phenomena); *g*, anthelion, or anti-sun.

The illustrations of these three halos, in which the vault of the heavens is shown as a horizontal plane, convey a less accurate idea of the relative positions of the several typical forms than a projection of the sort shown in Fig. IV, which is reproduced from Besson's "Théorie des halos."

Besson's upper diagram shows the phenomena that may be seen in the portion of the sky opposite the sun, and the lower those that surround the sun itself. In both diagrams *O* is the position of the observer, *S* is the sun, and *m* is the *parhelic circle*, passing through the sun and running around the sky, parallel with the horizon. Like the other halo phenomena the parhelic circle may sometimes be seen in its entirety, but more often only fragments of it are visible. This circle is usually quite colorless, except at the points (*e, g*, etc.) where parhelia occur upon it, but it has occasionally been seen with a reddish border. An *oblique parhelic circle*—i. e., one not parallel with the horizon—was observed by Hall, in 1796. The circle in this instance had a very decided tilt, as its altitude was 54 degrees on one side of the sky and only 14 degrees on the other. A few other similar observations have been reported.

The common halo of 22 degrees radius is shown at *a*; the halo of 46 degrees radius at *b*. The halo of 90 degrees is not shown in this diagram, but parts of it will be found in Figs. I and III. This is called, after its discoverer, the *halo of Hevelius* and is extremely rare; only six cases of its occurrence have been recorded.

Above and below the halo of 22 degrees are seen, at *c* and *d*, what are known as *upper* and *lower tangent arcs*. Their shape and direction vary greatly with the altitude of the sun. As the latter rises in the sky, the ends of these tangent arcs approach each other until they meet, forming a more or less elliptical ring around the halo of 22 degrees. This ring, shown in several stages in Fig. V, is called the *circumscribed halo*. At still greater altitudes of the sun the circumscribed halo merges into the halo of 22 degrees, from which it can no longer be distinguished.

Upper and lower tangent arcs also occur in connection with the halo of 46 degrees. The upper, shown at *h*, is sometimes called the *circumzenithal arc*, and is one of the most brilliant and beautiful of all halo phenomena. Its colors are often remarkably pure; red below, then orange, yellow, green and sometimes blue and violet. This arc, which often occurs unattended by any other halo phenomena, is generally visible but a short time; about five minutes on the average.

Strictly speaking, the circumzenithal arc is not exactly tangent to the halo of 46 degrees except when the sun is at a particular altitude, viz., about 23 degrees above the horizon. At a greater or less altitude of the sun the arc lies some distance above the halo; though this fact is not easily established by observation for the reason that the two phenomena are very rarely seen simultaneously. Such an observation was, however, recently reported and figured by Besson[1]; in this case the two curves were separated by an interval of about 3 degrees. Hence precise terminology would require us to call this arc the "upper quasi-tangent arc of the halo of 46 degrees." Similarly, the lower "quasi-tangent" arc of the same halo—sometimes called the *circumhorizontal arc*—is supposed to be exactly tangent to the halo only when the sun is at an altitude of 68 degrees; but this arc is rarely observed.

At *i i* are seen what are known as the *infralateral tangent arcs* of the halo of 46 degrees. The points of tangency of these arcs with the halo of 46 degrees vary with the altitude of the sun. The higher the sun, the lower the points of tangency. According to theory—not yet confirmed by observation—when the altitude of the sun reaches 60 degrees these two arcs meet at their lower extremities, forming a single curve, called by Bravais the *lower bitangent arc*. The same theory requires that when the altitude of the sun exceeds 68 degrees this arc is no longer in contact with the halo of 46 degrees, but lies external to, and concentric with it.

An analogous pair of arcs (not shown in Fig. IV) may occur at the upper sides of the halo of 46 degrees. They are called the *supralateral tangent arcs*, and are excessively rare; in fact, only one unquestionable observation has been recorded, viz., that of Besson, who saw one of them September 26th, 1910.[2] According to Bravais's theory, these arcs, like the infralateral arcs, unite in a single curve—the *upper bitangent arc*—at a suitable altitude of the sun, viz., 12 degree or more.

At *e* and *e′* we have the commonest of the *parhelia*, or sun-dogs, viz., those belonging to the halo of 22 degrees. Their position with respect to this halo varies with the altitude of the sun. At low levels they are in contact with the halo, but as the sun rises they move away from the latter, and thus lie outside the halo. These parhelia occur in the parhelic circle, described above, and very frequently only fragments of the latter are visible, extending away from the parhelia, of which they then constitute the so-called "tails." (*t, t*, Fig. VI.)

The parhelia of the halo of 46 degrees are shown at *g* and *g′*. The term *parhelion* is also sometimes applied to luminous spots seen above or below the sun, at the point of contact of a tangent arc with a heliocentric halo; but these so-called *vertical parhelia* are usually much fainter and decidedly less sharply defined than the parhelia occurring in the parhelic circle.

[1] *La Nature*, Paris, 21 déc., 1910, p. 247.

[2] *Comptes rendus*, 17 oct., 1910, p. 693.

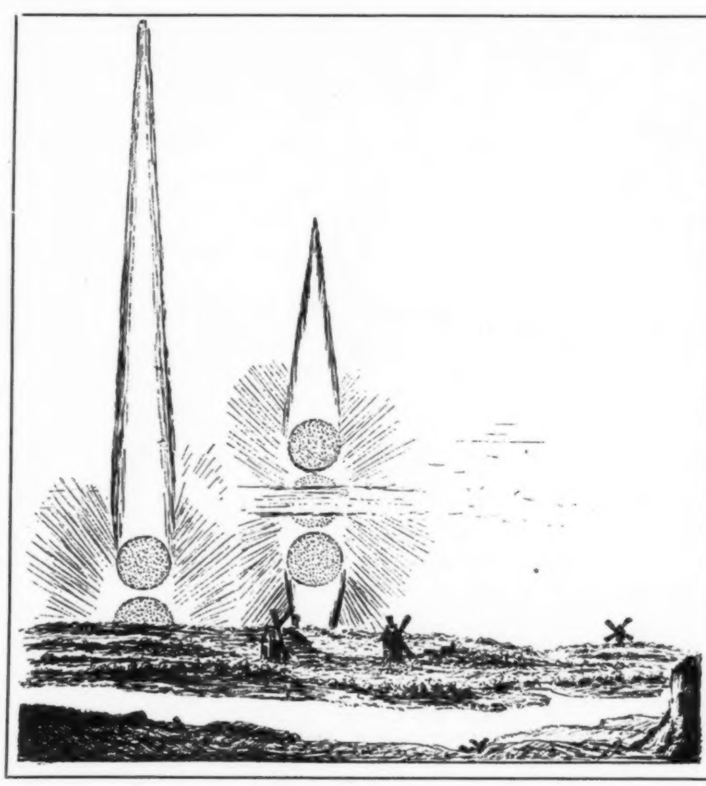


Fig. VII.—Mock-suns in contact with the real sun, accompanied by a sun-pillar. Two stages of the phenomenon observed by Hevelius, 1682.

The small arcs shown at *f* and *f′* are rarely observed. They are called the *arcs of Lowitz*, or lateral tangent arcs of the halo of 22 degrees.

At *u u′* is shown what is called a *light-pillar* (*sun-pillar* or *moon-pillar*, as the case may be). It is seen only when the luminous source is less than 30 degrees above the horizon. It never shows prismatic colors, but, in the case of the sun-pillar, may be reddened by the sunset. Sometimes a light-pillar occurs simultaneously with a fragment of the parhelic circle, the two phenomena thus producing what is called a *solar* or *lunar cross*. (Fig. VI.)

Turning now to the upper diagram of Fig. IV, we have at *n* the *anthelion* (also called the *anti-sun*, or *counter-sun*), which lies in the parhelic circle, opposite the sun in *azimuth*; in other words, if you turn your back to the sun the anthelion lies before you, at the same altitude as the sun. It is a brilliant image of the sun, usually pure white. The anthelion has been seen only about thirty times in the last 250 years.

At *r* and *r′* we have what are called the *oblique arcs of the anthelion*. Sometimes more than two are seen. The angle at which these arcs intersect is variable. Sometimes they extend far across the sky toward the sun. (Compare Fig. II.)

Finally, at *p p′*, *p* and *q′* are seen *paranthelia*, i. e., mock-suns occurring in the parhelic circle at a distance from the sun, in azimuth, of 90 degrees or more.

MISCELLANEOUS HALO PHENOMENA.

The foregoing list of halo phenomena is far from exhaustive. There are, for example, a number of heliocentric circles of unusual radius, which are classed together by Bravais as *extraordinary halos*, and each of which bears the name of its discoverer.

Several additions have been made to the list in recent years. All the "extraordinary halos" are extremely rare.

Sometimes a particularly bright halo phenomenon—usually a parhelion—may be the source of what are called *secondary halo phenomena*. Thus a parhelion of the halo of 22 degrees may be itself surrounded by a halo of 22 degrees (passing through or near the sun), etc.

A number of *extraordinary circumzenithal arcs* have been described, i. e., circles, or fragments thereof, parallel with the horizon, but in a position differing from that of either the parhelic circle or the tangent arcs above described.

An interesting member of the mock-sun family is the white image of the sun sometimes seen from a balloon or mountain summit, when the observer is looking down upon the upper surface of a horizontal sheet of cloud consisting of ice particles. The image lies in the same vertical line with the sun, its position corresponding to that of the reflected image of the sun seen on the surface of a body of water. This appearance, called the *pseudhelion*, should not be confused with the anthelion, which, as already stated, lies in the same horizontal plane with the sun, but opposite it in the sky. The occurrence of mock-suns in contact with the real sun, or nearly so, and in the same vertical line with it, has occasionally been reported. This phenomenon was seen by Hevelius April 10th, 1682. (Fig. VII.) In the few cases recorded the sun was close to the horizon and was attended by a sun-pillar. Pernter considers this a case of mirage; the mock-suns being refracted images of the real sun.

One important halo remains to be mentioned, viz., the *halo of Bouguer*. This occurs in the same position with respect to the sun as does the rainbow, and is of nearly the same angular size, but is due to the refraction and reflection of light by ice-crystals. As it is nearly colorless it is often called the "white rainbow." (The author has described true white rainbows elsewhere. See "Little-known Rainbows," SCIENTIFIC AMERICAN, April 6, 1912, pp. 305-306.)

Solar halos are best seen through dark-colored spectacles, and the observer should stand in such a position that the sun itself is behind the projecting roof of a building or some other opaque object, to cut off the blinding glare. In connection with drawings of these objects, all dimensions should be stated in degrees of a great circle of the sky, and the hour of the day should be accurately indicated. Halo phenomena are apt to be of very brief duration and should be sketched as rapidly as possible.

There is an interesting and important field of work open here, both for the professional meteorologist and for the intelligent amateur.

Approaching the Limit of Increasing Gold Production

Is Our Standard of Currency Nearing Equilibrium?

From the present outlook in the gold-mining industry of the world, gold production will have reached its maximum within the next twelve months, and it is possible that 1912 will show a positive decrease, says H. C. Hoover, in a recent article in the New York *Sun.*[1] Continuing with a review of the various countries in respect to their future gold production, Mr. Hoover said:

The placer gold of Europe was practically exhausted in Roman times. Lode mining there is a small industry and every foot of ground is known. In Asia the Chinaman has washed the gravels from Siam to Tibet and Mongolia centuries ago. In lode mining I can say from three years of exploration there that he has long since exhausted the mines down to water level and if mines do exist it will be a very slow business finding them.

NO GREAT EXPECTATIONS FROM CENTRAL ASIA.

I do not myself believe there exists in China or Central Asia a district of such importance as to materially affect the question, for no greater illusion exists than that the Chinaman has any prejudice against mining for gold—when he can make a profit. And he can make lode mines profitable by hand labor on which we could not earn a cent with the finest machinery ever built.

In India mining has been going on for thousands of years. The placer deposits are exhausted and in the only lode-mining district of importance we discovered the mines are now 3,500 feet deep and are becoming very difficult to operate. India has been decreasing its output for the last six years, and it will inevitably continue to do so.

In Asia Minor the alluvial gold has been exhausted since Crœsus's time. There may be some lode mining, but it is a striking fact that none of the districts that were worked by the ancients—and they worked everything they could find—give any evidence of large volume.

In Egypt hundreds of ancient workings have been opened up during the last few years to the grief of the operator. In fact all mines in these old civilizations, Egyptian, Chinese, Central Asia and India, were worked by slaves or convicts who were fed with impressed food so that all of the metal was profit, and thus hundreds of deposits were worked which prove of no use to the modern operator with all his appliances. And it is scarcely probable that the ancients deliberately chose the worst deposits.

In Australasia, the placer industry is in its dotage. The lode districts within the periphery of say 300 miles from the coast line, are in their decadence, the great interior desert is partially unknown but has in recent years been much traversed. The districts in the interior so far discovered, such as Coolgardie, Kalgoorlie, etc., are all decadent. The maximum output from Australasia was reached about five or six years ago, and it has been steadily decreasing ever since.

U. S. DREDGE PRODUCTION HAS PASSED ITS ZENITH.

Placer mining in the United States made a recovery from apparent extinction a few years ago by the rise of the dredging industry; this has passed its zenith and the output will soon begin to decrease if it has not already done so. Lode mining has had no accessions since the Nevada discoveries of ten years ago. Altogether the outlook is decidedly toward diminution of the output, for lack of sufficient new recruits to fill the places of those producers now imminent of death.

Canada poured a vast quantity of gold out of the Klondike hand-worked placers, but that stream has become but a trickle from the giant dredges now being built to work over the leavings of the early pioneers. Elsewhere, even with Porcupine thrown in, that country cannot, from anything in sight, maintain its average of ten years ago, although the unknown territory in that country is nascently more pregnant of new mines than the now well prospected countries further south.

Siberia has been vaunted as the future gold source of the world, and gold is wonderfully distributed over that country. But so are dismantled mills and abandoned dredges—a confirmation of the opinion of all engineers of experience in that region, that but little of the area promises profitable mining. Some hope does, however, exist for successful new dredging areas in the extreme Northeast.

South and Central American placer gold was practically all seized by the Spaniards. The lode mining has had English capital poured into it for generations. One company is over a century old. And on balance only a loss has resulted.

THE RAND WILL NOT INCREASE ITS OUTPUT.

On the Rand, which produces over one third of the world's gold, the mines are already becoming fairly deep (there are considerable workings at more than 3,500 feet), the ores are becoming poorer with depth, the profit to be won from the shallower areas was vastly overestimated, labor and physical conditions are steadily becoming more difficult, working costs are rising and grade of ore falling. This district will certainly not materially increase its output, and I should not be surprised to see an appreciable decrease within twelve months. It will go on producing gold for fifty years, but in steadily diminishing quantity and even ten years will see a great decrease.

Outside of the Transvaal, there are two large areas known in Africa, that is Rhodesia and West Africa. The gold deposits of Rhodesia are mostly the erratic quartz type, and *en bloc* cannot be expected to return the money invested. The British public has invested this money under the glamor of the Rand, and will not repeat very often the game of spending $20 of labor and material to get $10 in gold.

West Africa has been vastly overestimated, and the tombstones of English companies who have been operating there are now being set up by the score. There are some unexplored places on that continent but they are much less than is currently believed by those unfamiliar with the vast amount of prospecting that has been in progress during the last fifteen years. Large areas of the Congo Free State, Uganda, Nyassaland, Nigeria, Sudan, Sahara, etc., have been demonstrated to be geologically unfavorable, and the probability of any gold industry is of the remotest kind in these territories.

OPPORTUNITIES FOR IMPROVED METHODS NOT IMPORTANT.

It is not my point that no new mines will be discovered; it is that great districts are unlikely and that the annual supply of new isolated mines will not replace the frail and dying members. The great opportunities for the application of newly discovered methods have all been taken advantage of; no industry has had such a generous supply of capital for every warrantable enterprise. Further the opportunities for improvement on modern methods, and thus the renewed play of lower-grade or refractory mines, are no longer of importance. The increase in percentage recovery from 60 per cent to over 90 per cent offered many opportunities and realized much increase in production, but the region for expansion between 92 per cent and ultimate 95 per cent is small.

The cost of working has been reduced to near bedrock by mechanical equipment, until the room for further improvement amounts to cents per ton and not dollars as it was formerly. And in this last connection the cost of wages and supplies in this industry is increasing like all others and will more than offset any reduction due to improved methods. The working costs on the Rand, in Australia, in Russia and elsewhere show a considerable rise during the last two years. This in itself will tend to diminish the output.—*The Engineering and Mining Journal.*

[1] "Are We Near the Gold Output Limit?" by H. C. Hoover, *The Sun*, September 8th, 1912.

Does Baking Sterilize Bread?*

Whether bread is sterilized in the process of baking is one of the questions not yet decided. While some bakers claim that the center of the loaf never attains a very high degree of heat, others contradict them and a general consensus of opinions is out of the question. Recently a French scientist has been investigating the matter and his report was reviewed in a recent issue of the French trade paper, *La Boulangerie Française.*

In dealing with the subject, the writer says that he had previously drawn attention to the recent works of Dr. Auché, professor in the Faculty of Medicine and Doctor to the Hospital at Bordeaux, upon the destruction by baking of pathogenic microbes contained in bread. Some scientists, such as Aimé Girand and Balland, long ago demonstrated that in every case the interior temperature of loaves reached, and even slightly passed 100 degrees. In 1907 M. Roussel published a work in which, while recognizing that the interior of a loaf reached a temperature from 100 to 103 degrees, he showed that the bacillus of Koch, the microbe of tuberculosis, resisted that heat. Dr. Auché, in 1909, took up the research of M. Roussel, and succeeded in proving that the Koch bacillus introduced into a halfpenny loaf and penny loaf and one kilogramme and two kilogramme loaves were killed by the heat of the oven. He did not stop at that, however, for he desired to extend his investigations to all the microbes of the chief diseases. To follow the account which was given by Dr. Auché at a meeting of the Biological Association of Bordeaux, he says, at the meeting of May 4th, 1909, he demonstrated that the tuberculosis bacilli incorporated in dough of different sizes always lost their virulence after baking. M. Laveran, in a report made to the Council of Public Hygiene and of Health of the Department of the Seine, has quoted that work and accepted the conclusions from it. But the bacilli of tuberculosis are not the only pathogenical agents which can be introduced into dough. Many others can be introduced there by water, flour, from the hands of the bakers or by any little particles of saliva which fall into the trough while the dough is being made. The knowledge of certain carriers of bacilli allows us to suppose that sometimes infections can be made by their intermediary, and that in this way there can be incorporated in the dough the bacilli of diphtheria, meningitis, pneumonia, bacilli d'Eberth, the bacilli of dysentery, etc. It was probable, seeing the high temperature of the baking of the bread, that all these microbes were, like the bacilli of tuberculosis, destroyed by baking. However, as M. Roussel in his experiments had seen his fields of culture increased, it was not without interest to examine experimentally the kind of microbe agents introduced into the dough. In place of using the method of inoculation, as we did for tuberculosis, we employed the method of cultures. A soup culture of two days was strongly colored with the neuter tint of litmus and inserted by the aid of a sterilized pipette into the center of two unbaked loaves in the laboratory. The dose injected varied from a half to one cubic centimeter. Of the two loaves one was a small half-penny loaf and the other a round loaf weighing one kilogramme. Immediately after the injection of the cultures the two loaves were carried to the bakery and baked with the other loaves from the same batch. The next morning the loaves were taken again to the laboratory and opened with care in a perpendicular way, following the line of the pipette, which was easily recognized by the red color given by the soup. Some small red pieces of crumb were collected by the help of perfectly sterilized instruments and placed in bouillon tubes. Other pieces were placed at the extremity of a thin wire of platinum which was stiff and rubbed on the surface with tubes of inclined gélose. The tubes were placed in a stove at 37 degrees.

For these experiments several different pathogenic microbe agents were used, typhus bacilli; paratyphus bacilli B.; the bacilli of dysentery, type Shiga and type Fluxner; golden staphylococci and a variety of others. It is probable, however, that nearly all the bacteria would behave as the preceding. However, it is probably not the same with microbes which successfully resist heat, such as the bacillus of tetanus. This fact deserves to be studied. Whatever it be, here are the results which were obtained with those which were employed. With typhus bacilli, after three days all the culture remained sterilized. The absence of microbe development did not depend on the reaction of the medium which the acidity of the bread would have been able to modify, for sown with pure cultures, all the tubes grew abundantly. However, the reaction of the bouillon remained slightly alkaline. Paratyphus bacilli B. gave the same negative results. Dysentery bacilli type Shiga and type Fluxner gave the same negative results, as also the colon-bacilli and the other bacilli. All the mediums of culture resown with some pure cultures of the different microbe agents used in the experiment gave cultures. The conclusion which is drawn from these experiments is that all these cultures of bacilli introduced into the loaves of the sizes used were completely destroyed by baking. However, the pathogenic agents introduced into the dough by the water, flour or from the workers, which would be great in number and incorporated into the dough in place of being put into a liquid medium as in the experiments, would be more easily and completely destroyed by baking. Other experiments have been made on several occasions with the crumb taken from the ordinary bread delivered for consumption, and they always gave negative results. Scientists, therefore, conclude that bread (excluding any pollution of the exterior after coming out of the oven) ought to be considered an an antiseptic food.

* Reproduced from *Pure Products.*

Weight of Trains

The extreme weight and speed of modern railway trains is a train weighing 400 tons moving at a velocity of 75 miles an hour. Many people are amazed at the destruction effected by railway trains when they strike an object at rest, such as a delayed train. A mass of 400 tons propelled at 75 miles an hour contains energy nearly twice as great as that of a 2,000-pound shot fired from a 100-ton Armstrong gun. No wonder that such a train proves a terribly destructive projectile.

The Effect of the Automobile on Railway Traffic*

A few years ago steam railway officers were considerably exercised on account of the actual and prospective inroads on their passenger business caused by the rapid development of the net work of electric interurban railways, with their smokeless, frequent service and low fares. Many railway officers are now alarmed because of the effect of the automobile on their passenger business. While some have deemed it too insignificant or inevitable for serious consideration, others have investigated the subject and have been able to trace distinctively appreciable losses in earnings to the increasing popularity of the automobile. While difficult to measure, these losses are felt in the earnings from local, short haul business, and also in those from long haul business because many people in comfortable circumstances, who formerly took summer vacations involving railway journeys, now take their recreation either in the form of motor tours or in daily pleasure riding.

A comprehensive investigation of the subject has been made by the Union Pacific, much of whose road lies in a prosperous territory, the physical conformation of which is especially adapted to the use of the automobile. During the summer of 1911, in order to ascertain to what extent, if any, the use of automobiles was affecting local travel, Gerrit Fort, passenger traffic manager, addressed an inquiry to all agents on the Union Pacific and Oregon Short Line, and also questioned the principal wholesale houses in the territory of the two roads. This inquiry developed that exclusive of Kansas City and Omaha, but inclusive of Denver and Salt Lake City, there were 19,004 automobiles of private ownership along the two lines, 15,497 of which were on the Union Pacific and 3,507 on the Oregon Short Line. In addition there were 984 cars kept for rent. The average carrying capacity was probably five. While various other reasons were assigned for the decrease in passenger traffic experienced by the western lines that year a very large proportion of the agents of these roads mentioned automobiles as among the important contributing causes. Out of 50 replies from agents on the main line through Nebraska, 17 did not think that automobiles had affected the earnings, while 33 said that they had affected the local revenue, the estimates as to the amount of the effect varying from "slightly" to "50 per cent of the local sales." In Kansas out of 45 main line agents 14 stated that the short haul business was being seriously affected by automobiles. In Colorado 16 out of 27 agents estimated the effect from slight to one third of the local business. In Wyoming 24 out of 31 thought that automobiles had had no perceptible effect on revenue, while 7 believed that their business was reduced. On the Oregon Short Line the general opinion was that the automobiles had not yet perceptibly influenced local traffic.

The reports stated that the owners of machines used them to make short trips to neighboring towns, and carried with them people who would otherwise use the trains. An agent at a small town in western Nebraska said that on July 4 he sold 112 tickets to Lodge Pole, Neb., and that fully as many persons went in automobiles. As the round trip fare between these is 40 cents the company lost by automobile competition $45 or $50. An agent at Brighton, Colo., stated that automobiles were affecting the local revenue at his station to the extent of $150 a month. The agent at Granite Canyon, Wyo., said that six automobiles were brought in his territory during the season, and his local sales for June dropped 35 per cent and that most of the ranchmen in his vicinity intended purchasing automobiles.

Reports from shippers showed that many houses had bought automobiles for their salesmen, and that others contemplated doing so. The agents who found their station earnings affected stated that commercial men were using automobiles extensively, and often joined together in hiring them, figuring that the difference between the cost of renting a machine and the railway fare was more than offset by their ability to cover more territory in a given time, especially in localities served by only one or two trains a day.

Even in territory where there may be several trains a day automobile owners have found that they can frequently keep appointments and transact business within a radius of 10 to 25 miles far more conveniently, and with a considerable saving in time, although, of course, at far greater expense, by auto than by train.

P. S. Eustis, passenger traffic manager of the Burlington, also canvassed his agents during the summer of 1911 for an explanation of the temporary diminution of ticket sales. While a large number ascribed it to the poor crops of that year, a large proportion were able to specify several ways in which the increasing use of the automobile was cutting into the passenger receipts. For example, one agent reported that the ticket sales from his station to a town 14 miles away during the Chautauqua meeting showed a large reduction as compared with the previous year, although the attendance at the meeting was larger. During the year the number of automobiles in his town had increased by 25.

Although the summer of 1912 was far better from the passenger traffic standpoint than that of 1911, that the effect of the automobile is rapidly and steadily increasing is demonstrated by reports gathered by the Union Pacific in August, 1912. These showed that there are now upward of 25,000 automobiles in Nebraska, 18,600 in Kansas, 18,000 in Colorado, 1,500 in Wyoming, 2,300 in Utah, and 1,500 in Idaho. That is, there is one automobile for every 47 inhabitants in Nebraska, one for every 90 in Kansas, one for every 44 in Colorado and one for every 97 in Wyoming. Undoubtedly, therefore, the passengers earnings of the railways are being, and will continue to be, more or less seriously affected. Moreover, the effect of the automobile is felt particularly in the earnings of branch lines where the traffic is hardly sufficient to justify an increase in service, and where the loss of business renders it more difficult to meet the expense of a train or two a day.

With the improvements in country roads and in the design of motor trucks there is also growing up a competition with the railways in the handling of freight for short distances, particularly in congested terminal districts. It has been shown that a Long Island firm is successfully operating motor trucks between its factory at Glen Cove and its New York warehouse, and is not only handling its own products with a saving of time and freight rates, but is carrying small shipments for others in competition with the railway Some of the large department stores in Chicago have for several years used their own auto-trucks for the delivery of packages in the outlying suburban territory in preference to paying express rates. Many other instances have been noted where short haul freight transportation formerly handled by railway has been captured by the motor trucks. It was recently estimated that from the inception of their manufacture up to 1911 $60,000,000 worth of motor business vehicles had been sold. In Massachusetts the records show about 3,500 commercial vehicles licensed since January 1st, 1912, and in New York the automobile bureau of the Department of State reports 8,278 registrations of commercial vehicles this year, with from 80 to 250 being added each week.

It is difficult to see how the railways can expect to meet the competition of automobiles either for freight or for passenger transportation in such circumstances as those in which its greatest development has been shown to have taken place. As far as passenger service is concerned it may be found that the use of the self-propelled motor car, which has often proved an effective offset to electric line competition, is adapted to meet the conditions; and it may also be found useful in some cases for short haul freight transportation.

The optimistic view of the whole situation, however, is that both the automobile and the motor truck are agencies of transportation that make for good roads and better conditions of living, which will ultimately be helpful to the railways as well as to others. The railways certainly are vitally interested in road improvement; they derive large earnings from the shipment of automobiles, and if the traveling salesman is able to sell more goods by their use the railways will surely profit as a result. At the same time it is not unlikely that the increased use of automobiles will have a tendency to slacken the building of interurban trolley lines. A few years ago it was thought that the extension of long distance telephone service would affect travel, but it is now generally recognized that while a telephone message very often saves a railway trip, in innumerable instances engagements are made over the telephone which cause travel or transportation which would not otherwise take place. As for motor truck freight transportation, its success as a competitor of that of the railways has been mainly determined by individual or local factors, and it has furthermore been greatest in the vicinity of the large cities where it has probably relieved the railways of some of their most expensive and least profitable traffic.

* Reproduced from the *Railway Age Gazette*.

The Economics of Water Power

Fixed Charges on Hydraulic Plants Often Forbidding

In these days when one hears with distressing frequency that a water-power trust is going to gobble up all the hydraulic privileges of value unless stopped by the big stick, it is not a bad idea solemnly to take account of stock and see how the water-power situation really bears on the cost of power. Analysis of power production costs on current data shows a situation radically different from that which was apparent ten or fifteen years ago. During the past decade the efficiency of power production by steam has increased as respects plants of first-class modern design by at least 25 per cent. A large modern power plant operated at load factors now attainable in electric practice will produce a kilowatt-hour on less than 15 pounds of steam where the earlier plants, also of the best design and worked at substantially the same load factors, will hardly do better than a kilowatt-hour for 20 pounds of steam. Indeed the 15-pound record has many times been broken, even in foreign practice, by small reciprocating units worked at high superheat. Of such order of magnitude, at least, is the general difference between the skilfully designed turbine plant of to-day and the compound condensing engine plants of day before yesterday. The change has been in part produced by the coming of the turbine; in part perhaps because of the vacuum and superheat that the turbine has brought with it.

As a result of this very considerable change for the better in the economy of power production based on coal, one is forced at the present time to look askance at water-power privileges that exist under anything like adverse conditions. It is perfectly true that a good water-power plant, well loaded so as to keep down the fixed charges, can turn out power at a very low figure, but it is equally true that a modern steam plant designed for the advanced practice of 1912 can surpass, at any reasonable fuel cost, a considerable proportion of the water powers now in use. It is very doubtful, for instance, whether the great water developments for textile purposes on some of the New England streams would ever be installed under present conditions of steam generation. Some of these privileges are so good that they should show up better than steam at any recorded price, but the investments on others have been so prodigious that the real financial history of the operation would be anything but cheering. Operating costs below half a cent per kilowatt-hour are getting to be common and even with the addition of fixed charges on the plant two thirds or three fourths of a cent per kilowatt-hour is quite within reach, assuming anything like full load conditions. Now a well-situated hydraulic privilege which can be economically developed can undoubtedly better even the best of these figures. But there are very many instances in which the fixed charges on hydraulic plants are forbidding. For example, a certain small New England water power, electrically developed, has cost its owners on their own book valuations no less than $280 per kilowatt of generating capacity. This implies a fixed charge of $14 a year per kilowatt plus all repair and depreciation charges, all reckoned at the switchboard and with the additional handicap that the generating plant can only be worked at its rated capacity for ten or twelve hours per day during nearly half the year.

When the facts are set down in cold blood a good many other hydraulic plants will be found in which the necessary charges aside from operation are quite as big as in this case, amounting, all things told, to $20 or more per kilowatt-year. Under such conditions it is perfectly obvious that the only economic salvation of the system is a much more complete use of the power throughout the year than is usually found. If such a plant operated, for instance, at full load 3,000 hours per year there would be a fixed charge of two thirds of a cent per kilowatt-hour against the power generated and even this would demand 100 per cent load factor during the 3,000 hours of use. At 50 per cent load factor the situation would be equally bad at 6,000 hours use, which is far greater than would usually be attained in any working plant. Cases like these, with which every hydraulic engineer is familiar, make it pretty evident that a good deal of care must be exercised in developing a water power to make it an economical success as against a thoroughly modern steam plant. Of course, where the market is ample and the cost of fuel high the hydraulic plant wins out nearly every time even now. Where the head is low or the situation so unfavorable that the fixed charges run up as they do in the instance cited and many others like it, the balance of economy for the present tends to swing the other way. Comparisons made a decade ago are no longer valid and if the "water-power trust" is not careful it may find that it has grabbed up the privileges of deficit rather than profit.—*Engineering Record.*

Selected Types of Modern Machinery

The International Exhibition of Engineering and Machinery at Olympia, London

[In a recent issue of Engineering Mr. J. Horner gives a very excellent review of some of the principal exhibits on view at the International Exhibition at Olympia, London, England. We reproduce here a few selected examples.]

LATHES, MILLING AND GRINDING MACHINES.

The turret-lathes form a group in which the turret is the one and almost the only basis of similarity. Such of these lathes as have been most highly developed may be justly regarded both as highly specialized machine-tools and as combination tools. To which class they may be relegated depends on the way in which the subject is regarded. If considered simply as machines, they are certainly very highly specialized; but if regarded from the point of view of variety of studied and compared in detail, numerous later improvements are apparent which make for increased efficiency. Regarded, therefore, from this point of view, the modern turret-lathe is a highly specialized and most efficient machine. If we look at the fittings of the turret and of the cross-slide in their higher elaborations we see a congeries of tools and appliances which are designed, constructed, or modified in hundreds of different ways to adapt them for dealing with the varied castings or forgings tooled in the lathe. They afford excellent examples of combinations of tools, though in a different sense from that which we usually understand in machine-tool design. These two aspects are suggested by the different forms in which the lathes operations, they are better representative of combination types than many machines classed as such. Turning, facing, boring, and screw-threading were the primary functions for which the early turret lathes were built, work which they appropriated from the lathes and screwing-machines. All the multitudinous details of present-day construction, the self-acting devices, the coarse and fine adjustments, the facilities which are provided for rapid changes by automatic methods, or nearly all of these, were and are absent from the ordinary designs. These devices have for their object the saving of time, which, apart from their help, is occupied in tentative adjustments, settings, and measurements. Moreover, each one is so designed in regard to its action, its strength, and stability, as to fulfil its function in the most efficient manner. Having no other duty to perform, every item which makes for efficiency is correlated to its particular function.

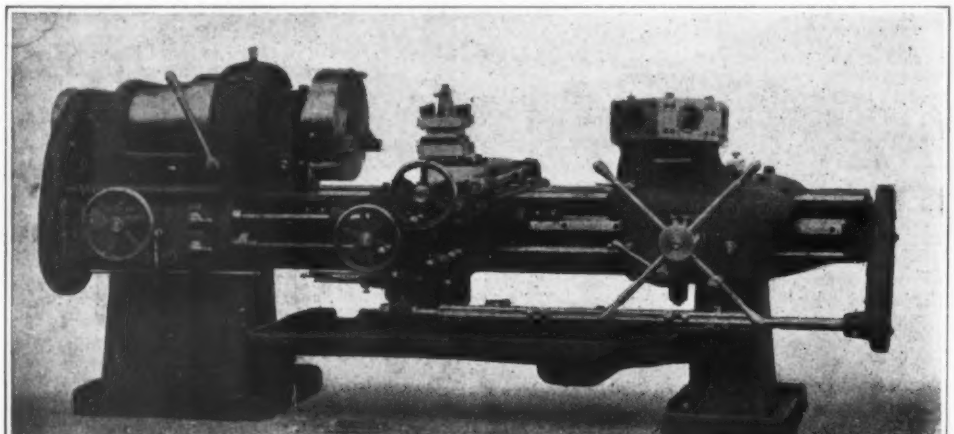


Fig. 1.—92-inch Center Combination Turret Lathe.

If we omit the cone drive, there is no very great difference in the external and general aspect of high-class turret-lathes of the leading types as made now and, say, ten years ago. But when these lathes are displayed by one of the exhibitors are built and the details of their construction. They include the capstan lathes, the hexagon turret-lathes, the combination turret-lathes, and the automatic turning-machines, which are also lathes with turrets. The combination turret-lathes are made in a series of four, which range from 9-inch centers to 11-inch centers (Fig. 1). The following observations relate in the main to all the lathes, with some variations to be noted.

In the first place, although the pattern of headstock with a three-stepped cone is built, the single pulley-head fitted with gearing is also manufactured. The 9-inch-center lathe takes a 4-inch belt, and requires 5 horse-power; the second a 6½-inch belt and 7 horse-power, the lathe being of 11-inch centers. In the first case three steps on the cone and two counter speeds give 12 spindle speeds. The same steps with one counter speed give six reverse speeds. For the 11-inch-center machine there are three counter speeds and 18 spindle speeds. With the single pulley-head on the 9-inch machine there are 16 speeds in each direction. Four speeds in either direction can be instantly obtained by friction clutches. The single pulley is mounted in ball-bearings. The thrust of the spindle is taken by a ball-thrust bearing. The bearings are of gun-metal lined with white metal, and are lubricated by syphon oilers. The spindle-nose is flanged, and bars 3½ inches in diameter can be put through the 9-inch-center lathe, but the one of 11 inches center is made to receive 5½-inch bars.

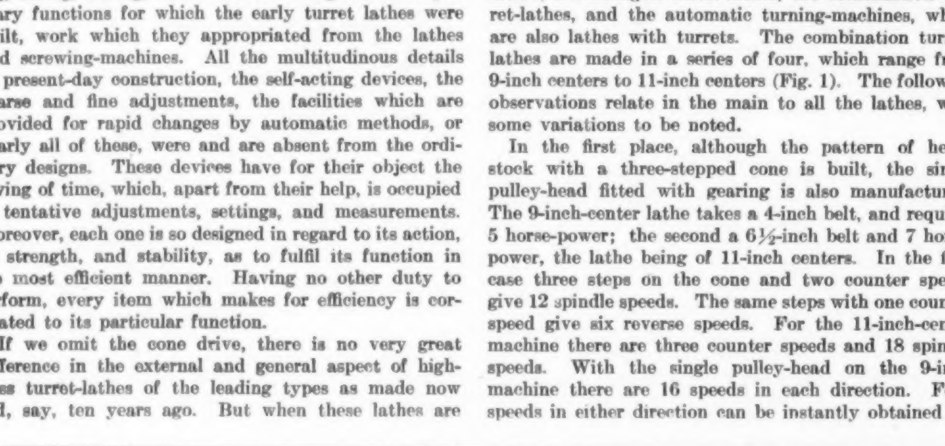


Fig. 2.—Automatic Turning Machine.

The movements by which the work is tooled are, however, those which possess most interest to a prospective user. These include three main elements: The hexagon turret, the cross-slide, and the screw-chasing apparatus. The turret is of the usual hexagonal form, inclined to permit long tools to clear the pilot handles in front of the slide. Its slide is fitted with a long, narrow guide to the front shear only of the bed, to which it is clamped instantly by a long, tapered gib moved endwise with a hand-lever. This slide is lubricated from the inside to prevent dirt from working inward. The apron of the turret-slide is fed in each direction at eighteen different rates in all these lathes. It incloses a change-gear arrangement by which the relative feed rates of the turret-slide, and of the saddle of the cross-slide which carries the square turret, can be changed. The object of this is to combine a coarse turning feed from the saddle with a fine boring feed from the turret when both operations are simultaneous. Each face of the turret has its own self-selecting automatic stop, which acts as a dead-stop. On the six faces box tools can be bolted. Through the holes boring-bars, drills, and reamers can be carried, or long bars driven from the head can be passed through them. To insure very accurate results in lengths, an indicator is used, consisting of a disk which rotates with the shaft of the cross-handle. On this disk are three adjustable dogs having index lines marked on them. The boss on the slide has a fixed disk having three lines marked to correspond with those on the dogs. If, when the turret-slide is held hard up against a dead-stop, one of the dogs is set so as to come opposite one of the index lines on the boss, the indicator insures by its position uniform pressure on the dead-stop, independently of any changes of pressure on the cutting tools as they become dull with use.

The saddle of the cross-slide has nine feeds, alike in the longitudinal and transverse direction, set by the rotation of a hand-wheel, the feed in use being indicated on a dial, both being interlocked in relation to each other and to the chasing apparatus. Both feeds can be reversed. Both motions have automatic and dead-stops with fine adjustment screws. The cross-slide carries a square turret of a solid-steel forging.

The chasing apparatus in these lathes comprises a leader driven by gearing in the feed-box at the front left hand of the bed and a nut engaging with the leader. Seven leaders form an equipment, and either one will cut pitches which are multiples of its own pitch in the ratio of 1, 2, 4 in the 9-inch-center lathe, or 1, 2, 3, 4 in the 11-inch-center series. These are changed by a lever at the feed gear-box. Right or left-hand screws can be cut, as desired, by the movement of a lever. The withdrawal of the nut from its leader withdraws also the tool or chaser from its cut.

Automatic turning-machines are represented by one of 19 inches swing (Fig. 2) on which 3-inch cast-iron flanged couplings are being tooled. The machine combines mechanism peculiar both to the turret-lathe and the automatic screw machine, with its cam-operated movements derived from a drum-shaft below. To increase the efficiency of the turret, it is supported by an overhead arm attached to a stiff central pin in the center of the turret. The machine is unique; its output is tremendous, fairly large pieces being tooled in it at prices measured by a few pence each. There are some differences in detail in the smaller and larger machines, but they do not affect the general design. The headstock contains the driving-gears inclosed in oil, driven by belt-pulleys from a self-contained counter-shaft, or motor driven. In either case sixteen spindle speeds are available. Four ratios of speed changes are obtained without changing any pulleys or gears. Two ratios are obtained in the gears by moving the handle in front of the head. The starting and stopping lever actuates a brake which brings the spindle quickly to rest as soon as the belts are on the loose pulleys, which pulleys run on annular ball-bearings. When a cycle of operations is completed the belt is moved automatically on to the loose pulley, thus stopping the machine to permit of taking out the finished piece and inserting another. The spindle is hollow, to permit of using draw-back arbors and draw-back collet-chucks. The spindle-nose has a flange

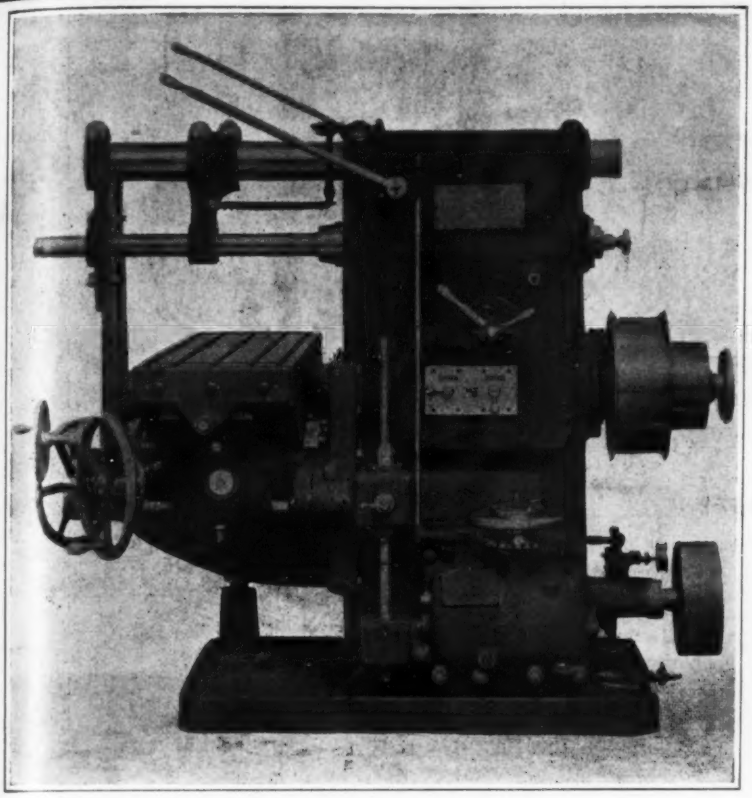


Fig. 3.—Pillar-and-knee Horizontal Spindle Milling-machine.

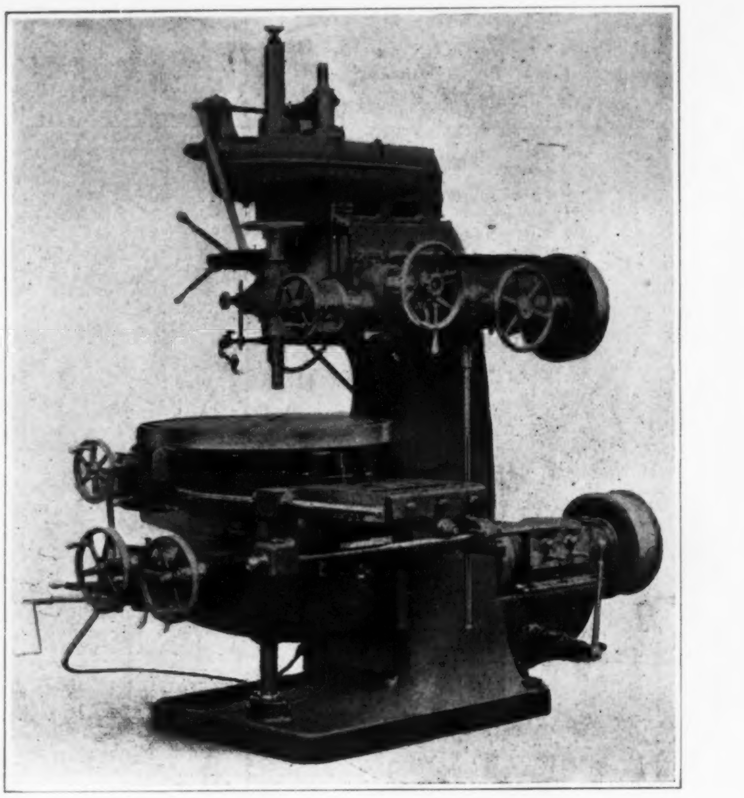


Fig. 4.—Vertical Milling Machine.

forged solidly with it, to which the chuck is bolted directly, so reducing the overhang. The thrust is taken by a large ball-bearing. A boring-bar support can be fitted in the hole in the spindle, to enable boring-bars to be piloted through. The capstan is square, and its flat faces are grooved for the ready adjustment of tools, and tools from the firm's capstan lathes will interchange on these. By means of a shock-absorber the indexing-bolt is relieved of the momentum due to rotation, and this, with the overhead support, tends to steadiness of operation and durability. The capstan slide and its drum are adjustable by rack and pinion relatively to the chuck to suit work of different lengths. The top slide has an additional rack and pinion to facilitate the setting of the tools. Each tool has its own adjustable dead-stop. The cam-drum by which the capstan is operated is boxed in and revolves in an oil-bath. For each cam there are seven feeds, which are set automatically as each tool comes into action. A disk, seen at the right-hand end of the machine, carries six adjustable change-feed dogs, four for the capstan and two for the cross-slide tools. The dogs can be set anywhere round the disk, grooved for the purpose. Each dog has seven holes corresponding with the seven feeds, and is provided with a pin to be placed in the hole that corresponds with the desired feed. As the cam-shaft rotates, the pin sets the feed before the tool begins to cut. The range of seven feeds can be raised or lowered in rate by change-gears, giving fourteen feeds in all for each cam. The cam-shaft and the feeds derived from it are driven from the headstock, but the idle motions are driven at quick and invariable speeds from a constant-speed shaft at the back of the machine.

There are two cross-slides, at the back and front of the machine respectively, each with its own adjustable cam and return-cam. They are adjustable independently along the bed, and can operate either at the same time or separately. Roughing and finishing cuts can be taken simultaneously. Each cross-slide has its own adjustable dead-stop, and a screw adjustment to regulate the diameter being turned.

Pillar-and-knee horizontal spindle milling-machines are represented by a single-pulley machine of large capacity (Fig. 3) having a longitudinal travel of table of 42 inches, a cross travel of 13½ inches, and a vertical travel, measured from the center of the spindle, of from 1 inch to 21 inches. The power of the machine may be gaged from the fact that it can absorb as much as 12 horse-power. Its net weight is 8,652 pounds. The machine at the Exhibition is taking a heavy cut on cast iron, using a cutter 9 inches wide. It will take a cut 8 inches wide and 0.65 inch deep with a feed of 9¼ inches per minute, removing 48.1 cubic inches per minute. It is a machine, therefore, of very great power, often termed the "plain manufacturing type." If its features are studied in detail, they present a large number of very interesting aspects.

To begin, the drive takes place from a single-belt pulley, and this runs on annular ball-bearings mounted on a stationary sleeve fixed to the column. There is thus no belt pull on the driving-shaft, and friction is reduced to a minimum. The machine is started and stopped from the pulley by one of the firm's friction-clutches on the first driving-shaft, operated by a hand-lever easily accessible from the front of the knee. A motor-drive is often substituted for that of the pulley. Both speeds and feeds are changed by gears, the first are inclosed in the column, the second in a box at the base of the column. The speed-box is a separate unit, which can be removed bodily from the interior of the column. It contains all the driving-gears except two which are keyed tightly on the spindle, and provides sixteen speeds to the spindle in geometrical progression and in either direction, the spindle being reversible to suit special operations. The speeds range from 16.4 to 427 revolutions per minute. Sliding-gears are used in preference to other methods. The driving-gears fast on the spindle are larger than any cutter which is used, thus insuring a smooth drive. A useful speed-plate shows how to obtain any speed, and gives by inspection the proper surface speed for cutters of different sizes. The gears are of hardened steel, and are flooded with oil by a force-pump within the column.

The feed gear-box, also similarly supplied with oil, provides the longitudinal, cross, and vertical feeds, all reversible by a single hand-lever at the front of the knee. The gears are driven by a single pulley from the first driving-shaft, the belt being preferred to the use of chains and shearing-pins, as a safety device. The feed-pulleys, like the main driving pulley, run on annular ball-bearings. Eighteen feeds are obtained by gearing ranging from 5/8 inch to 22½ inches per minute. These are selected by the firm's patent dial feed motion, the dial being located on top of the feed-box. The dial is simply rotated until the number that corresponds with the feed required comes opposite the pointer. Feeds are interlocked, the handles for engaging them having safety stops to prevent them from being moved too far when disengaging one feed, and thus accidentally engaging another. Shafts with gears transmit the feeds to the knee, universal joints being avoided.

The table is actuated by a fixed screw of quick pitch, which is always in tension, and as it is not splined, the life of the nut is prolonged. The revolving nut, of phosphor-bronze, is in two lengths, to provide adjustment for wear, and its over-all length is nine times the

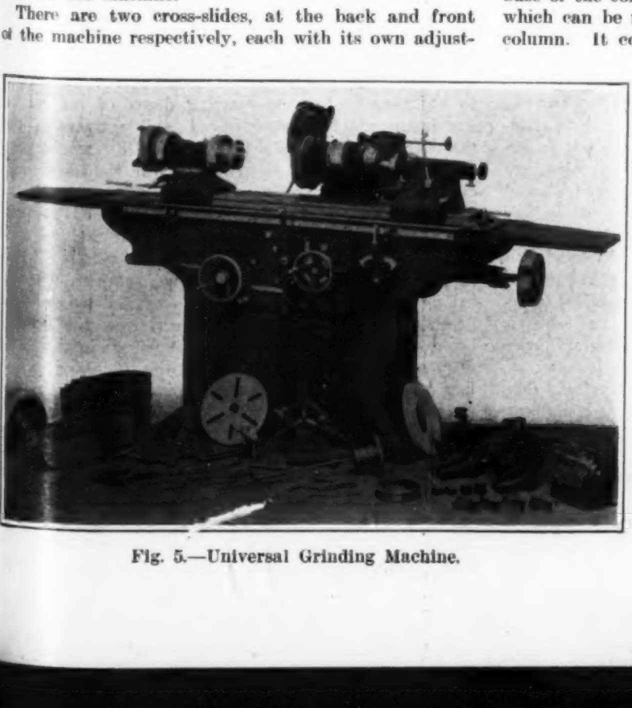


Fig. 5.—Universal Grinding Machine.

Fig. 6.—Twist Drill Grinder.

Fig. 7.—Wet Tool Grinder.

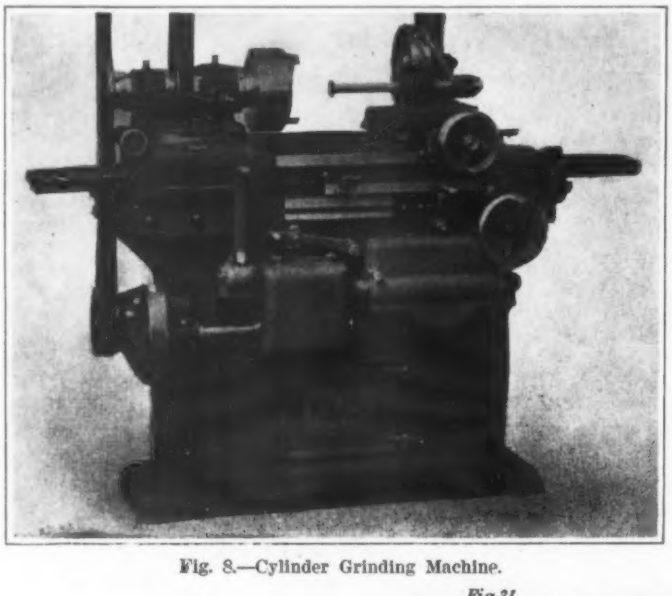
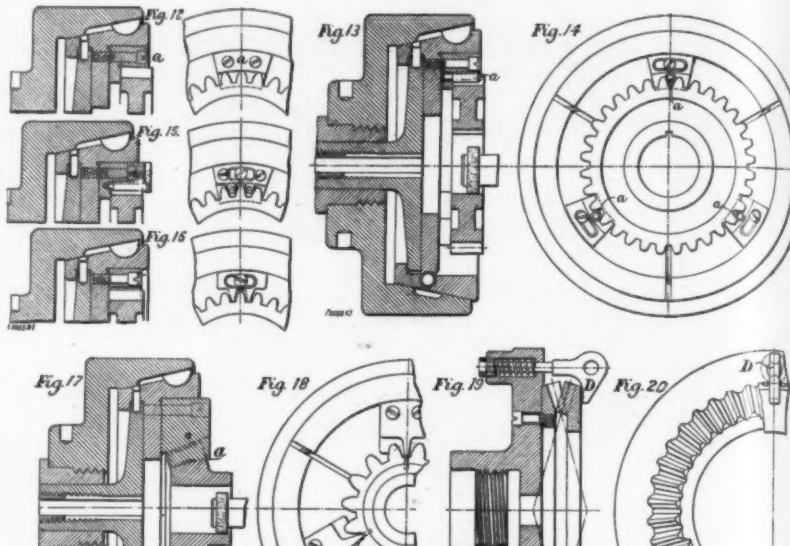
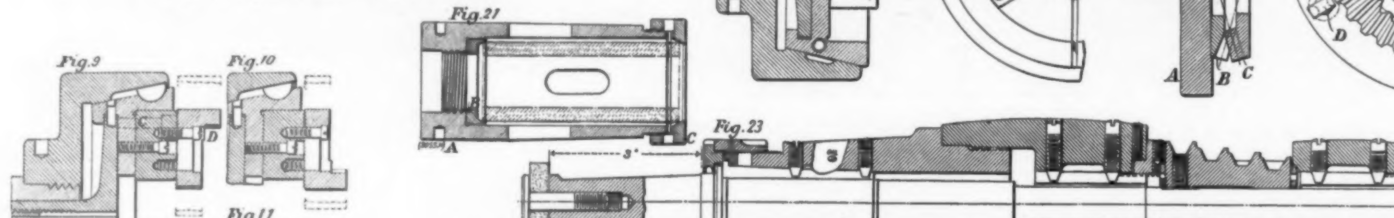


Fig. 8.—Cylinder Grinding Machine.





Cylinder Grinding Machine—General View and Details.

diameter of the screw. It is driven by wide steel spur-gears instead of bevel-gears. The thrust of the feed is taken by a large ball-thrust bearing. The cross-feed nut and the thrust-bearing of the cross-feed are adjustable for wear. Both this and the automatic vertical feed are engaged and released by handles at the front of the knee, each with an indicator plate to show the method of operation. All the feeds have automatic stops in both directions. In addition to the ordinary stops, each has a safety stop to disengage the feed just before the end of the rated travel is reached.

Many other automatic features must be passed over lightly. Nothing that makes for efficiency or solidity seems to have been overlooked. The principal castings are made in dry sand. The box form is adopted in column and knee. The knee is clamped to the overhanging arm. The table has a flush top, so that work can be supported over its entire surface. The T slots run right through, and a plate fixed at each end prevents suds from escaping. The table and cross-slide are oiled automatically and the flow of oil takes place from the inside, so keeping the slides free from dirt. The cross-slide has square edges and a narrow central guide with a taper gib. The saddle is gibbed and clamped to the outer edges. A smaller horizontal machine, which has many similar features to the foregoing, is also shown. It is taking a heavy cut in cast iron, using a coarsely pitched roughing cutter 5 inches wide.

The group of vertical milling-machines is represented by one of medium dimensions (Fig. 4). It has a longitudinal table feed of 48 inches, a transverse feed of 18 inches, a vertical adjustment of 16 inches to the table, and a circular table of 24-inch diameter. The machine takes 10 horse-power to drive it. Many of the details and devices embodied resemble those in the horizontal machines, being improvements or patented devices by the exhibitor, as pulley-drives, gear-changes, the dial-feed motion, pump lubrication, and so on.

The main spindle is driven from a single pulley, 16 inches in diameter, taking a 5-inch belt, running on ball-bearings mounted on the outside of a fixed sleeve, so avoiding belt pull on the first driving-shaft. Thence the spindle is driven by one of the firm's friction clutches through gears inclosed in a box and driving to the spindle-gears which are mounted on a fixed sleeve; this relieves the spindle from thrust due to the gear-teeth. The gears in the box provide eight speeds, doubled by a gear-change at the top of the machine, which speeds range from 17 to 400 revolutions per minute. All gears are of hardened steel and run in oil. The changes are interlocked and are read off on a speed-plate outside the box. The spindle is driven by keys on opposite sides. It has a tapered No. 12 hole with a box-clutch drive and a draw-bolt for arbors. The nose is tapered externally to receive large cutters. The diameter in the main bearing is 3½ inches. The latter is adjustable and of phosphor-bronze. The thrust is taken by washers of hard steel and white metal. The head is balanced, has quick adjustment by rack and pinion, and fine adjustment by worm gear, with a large index disk. A taper gib clamps the spindle-head along the whole length of its slide. A large annular T slot surrounds the spindle bearing, and receives a high-speed milling apparatus, to be noticed directly, and arbor supports or other fixtures.

The feeds number sixteen, ranging from 1 inch to 16½ inches per minute. They include the longitudinal and transverse movement to the table and the vertical movement of the head. The feed-gears are driven from a pulley belted from the first driving-shaft independently of the spindle speeds. They are put in according to the indications of the dial feed motion, are all reversible, and can be engaged or disengaged, altered or reversed, from the front of the machine while it is running. All have automatic and dead-stops and continuous lubrication. The circular table has hand and automatic circular feed by worm and wheel, but partakes of the automatic longitudinal and transverse table-feeds. The longitudinal feed-screw of the table is stationary, and the nut revolves. The tables and knee are elevated by a telescopic screw through bevel-gears, and the load is taken on a ball-thrust bearing. The lubrication of the gears and slides is effected similarly to that described in connection with the previous machine.

The same makers manufacture universal grinding-machines in 12-inch by 60-inch and 12-inch by 36-inch sizes, and one of the latter machines is exhibited. The engraving (Fig. 5) illustrates this, and the principal features may be rapidly run through. Two convenient arrangements are included, one being the reversible work-head, which has a dead-center fitting at one end, and a live-center at the other, each with its own pulley, so that either can be rapidly brought into alignment without changing any parts. The tailstock, which is furnished with a diamond-holder for truing the wheel, has a solid screw-feed, with spring center to permit of end expansion of work. The other convenient feature is the permanent inclusion of the internal grinding-spindle at the rear of the main-wheel spindle, so that by removing the wheel, and substituting a pulley to drive the internal spindle-pulley, the machine is ready for hole-grinding. To relieve the slender spindles of belt-pull, the driving-pulley runs on ball-bearings independent of the spindle, and a loose connection rotates the spindle. A parallel bearing receives the latter near the wheel, and a ball-bearing is situated at the inner end.

There are two automatic feeds, one for traversing the table, and the other for imparting cross-feed to the wheel-head, this latter occurring at the end of each stroke, and having a trip-motion to automatically stop at any desired size of work. Adjustment is provided to compensate for the wearing down of the wheel. An independent constant-speed pulley operates the table traverse, the rate being varied by moving the small vertical handle seen near to the right-hand end of the bed. Any rate between 7 inches per minute and 7 feet per minute is obtainable, while the table is moving, and this is useful while dealing with work having spaces that may be jumped across quickly to bring the wheel into operation on another shouldered portion.

The automatic table reverse is actuated by the dogs on the front of the table encountering the reverse lever, which also works the cross-feed lever. The dogs are locked by serrations on the underside of the bar on which they are adjusted, so that no dirt can clog the notches and interfere with accurate setting. When it is necessary to run the table past the stop limits, a dog may be swung upward to pass the trip-lever, and dropped down again without disturbing the accuracy of adjustment. A diagonal bolt arrangement is adopted for clamping the work-head and tail-stock to the table, thus insuring that the two heads are pulled over against one edge at every time of clamping. Clamp-

ing of the swivel-table, which turns on a hardened-steel pin fitting in a phosphor-bronze bush, is effected by the handles at either end, and a fine adjustment is provided for precise setting for taper grinding.

The back-rests comprise horizontally and vertically adjustable blocks of wood, white metal, brass, or other material, depending on the class of material being ground, each adjustment being made by separate screws. Inclosed spiral springs resist the pressure on the blocks, and the compression of these can be varied, or they may be rendered solid if required. A tank, mounted on pivots to render emptying and cleaning a matter that can be accomplished in a few moments, is located at the back of the bed, and the pump fitted to the tank is connected by a flexible hose to the hood incircling the wheel.

Not so very long ago it was considered a striking innovation when sensitive drilling-machines were fitted with ball-races to all the running spindles and pulleys, but the practice is rapidly extending to other types of machine-tools. One of the latest examples is manufactured by Messrs. Alfred Herbert, Limited, and shown at their stand, consisting of a twist-drill grinder, with the spindle, the countershaft, the loose pulley, and the drill-holder all mounted on ball-races. The advantages, apart from the ease of movement, are that adjustments are only required at long intervals, lubrication is only necessary once a year, and the moving parts keep cool under continued service. Rigidity is insured not merely by the strength of the parts, but also by the fact that the drill-holder has no weakening longitudinal movement, but the feed is given to the wheel bearings instead. Oscillation is imparted to the holder by grasping the ball-ended handle seen projecting to the left of Fig. 6, and the forked bearing in which the holder boss turns is clamped firmly in the split socket cast with the framing of the machine. Any sized drill within the capacity of the machine (that is, from 1/4 inch up to 2 1/4 inches in diameter), when placed in the V holder, is automatically set in the correct position to produce the proper clearance. The clearance angle increases progressively toward the center, giving the greatest possible amount of durability to the edge, this being produced by the position of the axis of oscillation.

The wheel spindle bearing, in which the spindle runs in dust and water-proof bearings, and has its end play automatically taken up by a spring, is moved along bodily by pulling at the handle seen projecting over the wheel-hood, and a stop arrests the travel of the wheel, so that each lip is ground equally. No pump is employed to supply the water to the wheel, because the rotation of the latter acts as a centrifugal pump, and raises the water from the basin, which has a water-level indicator. To keep the wheel in good shape, a truing apparatus is permanently at the back of the hood, and is operated, when desired, by manipulating a lever. On the other end of the wheel spindle a narrow thinning-wheel is placed for use when the webs of drills become thickened by repeated grinding off. It is protected by a guard, and a suitable rest is provided to support the drills while being thinned. Alternatively, a 12-inch steel disk for cloth or paper-grinding disks may be supplied for this end of the spindle, with a rest of plain type, or with a grinding fixture for sharpening the dies of the "Coventry" die-head.

The plain Lumsden grinder, shown in Fig. 7, is a small tool-grinder having a cup-wheel, working on the face. The wheel is 12 inches in diameter and 6 inches deep. Tools can be ground on either side of the face, an adjustable rest being fitted to each. Dry or wet grinding can be done. The wheel runs normally clear of the water in the pan. It is submerged by turning a hand-wheel, which lowers a float in the water, so raising the latter into contact with the wheel. A sheet-iron guard is arranged with means to direct the water to the front of the wheel. The machine is driven by a motor, but a countershaft drive can be fitted. It is put in and out of action by a pedal. All shafts run on ball-bearings.

The growth in the practice of grinding is reflected in a goodly array of machines of universal and of special types for cutter and tool-grinding, for cylinder, and hole and bush-grinding. Among the last, two types are shown, including those for cylinder-work and for internal grinding. Though both operate on bores, the differences in design are those associated with the planet spindle, dealing with articles too heavy to be rotated, and those of the plain spindle grinding rotating pieces. The differences are of a radical character, both in regard to the machine and the methods of chucking. The methods of holding work to be ground internally have to suit the two great groups of objects dealt with. Mainly the differences depend on whether the work done is ordinary internal grinding or that which though still internal, is termed cylinder grinding. The first deals with the smaller holes up to, say, 3-inch bore, the second up to 9-inch bore. The essential differences are that, in the first, the work rotates, and that, in the second, it is fixed, and a planet grinding-spindle is used. The work in the first being small and light, is chucked by methods similar to those adopted in the lathe and common grinder. In the second, it is held on tables with or without the interposition of jigs and fixtures.

Yet again the work of internal grinding is but one aspect of a larger but closely related, or indeed almost identical, group of manufactures developed by the practice of hardening running parts and the bearings of running parts. Bearings and spindles, gears, cutters, are ground after hardening. If they were finished with cutting-tools, they could not be hardened; or if hardened subsequently, they would have to be lapped as in the old style. No matter how hard and slender a bush or a gear may be, the grinding-wheel operated in a suitable machine will finish within fine limits cheaply and accurately.

The grinding of holes done on rotating pieces of work is a process developed from the old lathe practice, and is still embodied in some fittings made for use specially on lathes and others on bench-grinders. The highest developments are those of the internal grinding-spindles fitted to universal and plain cylindrical grinding-machines. The earlier designs, and those included in the bench-grinders are destitute of precision movements, the diameters having to be checked and arrived at by guess and trial. But in the cylindrical grinders the diameters are set by micrometric measurements, so that dimensions are precise without the necessity of taking trial measurements. These are embodied in the wheel-slides and their adjustments, which serve alike for external and internal grinding. Minute feeding adjustments are necessary in the work of grinding because of the incessant wear of the wheels. The problems and difficulties and precautionary measures which arise out of this fact are familiar.

With the growth in the dimensions of internal work, fixed and ground, the vertical-spindle machine has developed amazingly. Vertical machines for bush-grinding and lapping have long been used in the locomotive shops, but the vertical design has vastly more representatives than formerly, and with much greater range in capacities. The same arguments may be urged in favor of the vertical spindle-grinder over the horizontal as for the vertical boring and turning mill over the common lathe, the advantage being convenience of handling heavy masses, the visibility of the work being done, the falling away of the cuttings, the absence of overhang, the perfect balance, etc. But the horizontal machines are apparently as common now as the vertical. They seem to predominate in American and English practice.

The cylinder-grinder exhibited is of pillar and knee design. The cylinder is bolted either to the table, or inclosed in a jig carried on the table, which also imparts to the work the horizontal traverse or feed toward the wheel, parallel with the axis of the grinding-spindle. Double or multiple cylinders can be set and ground by the adjustments of the cross slide. Three feeds are obtainable by a change-speed gear-box. These act automatically, and reverse at any desired point. The wheel spindle rotates at a high speed in a slowly-revolving planet sleeve, within which it is carried round in a circle, which, plus the diameter of the grinding-wheel, is that of the diameter of the bore. Four speeds of rotation can be given to the sleeve by gears in a box to suit work of different diameters and varied materials, and three sizes of wheel spindle are fitted interchangeably. The radial feed or cut is put on by a ratchet wheel which can be operated while the machine is running, and rapid adjustments can be made with a crank. A pump and tank and an exhaust fan form a part of the equipment.

The internal grinder (Fig. 8) is one built for dealing with small holes as distinguished from cylinder bores. It does the same kinds of work which have been hitherto mostly put on the plain and cylindrical grinding-machines. But it is specially built for just the one kind of duty, for which the grinding-head spindle is set axially with the work spindle and supported by the base of the machine, and has speed and feed arrangements worked out for the one set of duties uncomplicated by the inclusion of duties of other and wider ranges.

In this machine the travel is given to the wheel-head, three speeds being available; one rapid for roughing, and two slower for boring and finishing. These are obtained from a gear-box mounted on the front of the base. Feeds are both by hand and power, also by a change-gear box on the front, and with adjustable table-dogs for reversing. Five speeds of rotation are provided for the work to suit different diameters of holes and also for roughing and finishing cuts in the same holes. These are obtained from a single belt drive and a quick change gear mounted on the overhead, and forming part of the countershaft. All these movements represent advances on the older design of stepped-cone belt-driven machines. Two belts only are used from the countershaft, one coming to the work-head and one to the driving-pulley, whence the wheel-spindle pulley is belted.

The headstock swivels on a bridge casting to any angle up to 45 degrees, on either side of the center line. The graduations are made both in degrees and in inches of taper per foot. The chuck-spindle is of high-carbon steel running in adjustable phosphor-bronze bushes, dust-proof. A 1 5/16-inch hole passes through the spindle to enable the collet chucks to be used for holding small pieces. The same hole does duty by serving as a channel to draw the dust through in dry grinding, and to serve as a water supply for wet grinding.

The wheel spindle is driven with V-shaped belts from the idler pulley at the rear, which is adjustable to maintain the belt tension on the short drive. It has two steps, one, the smaller, being belted from the counter-shaft, the other, the larger, driving to the wheel-spindle. As a range of several wheel-spindles suitable for different sized holes is supplied interchangeable on the slide, the endless belts used can be slipped off and on instantly. Two V belts drive on either of two pairs of grooves, larger and smaller, to give two speeds readily changed. The smaller steps are of value when wheels have become partly worn down.

Examples of hole-grinding done on the Heald internal grinder show its general handiness and the scope of its operations. Common face-plates and draw-in collets are both employed. The swivel of the work-head permits of angular settings. The illustrations (Figs. 9 to 22) show how the various jobs are held while these operations are being performed.

Common jaw-chucks screwed on the spindle nose will take many articles which have to be ground in the bores. A spur-gear may be held in plain jaws to have its bore ground. Opposite sides of a piece of work may be ground parallel and tapered respectively by swinging the head to give the angle of taper. If the tapered side is done first, a face-plate then has its edge turned to the taper, and the piece being turned round is placed over it and secured with a central bolt, while the parallel portion is being ground. Two bores in one piece, either parallel or tapered, can be ground at one chucking by simply moving the wheel inward or outward to suit the two radii. Details of the wheel-head and spindle are shown in Fig. 23.

A large volume of useful work is done, especially in gear-wheels, by the substitution of draw-in collets for the common chucks. It is a method valuable when gears have been slightly distorted by hardening. This comprises a chuck body screwed to the nose of the spindle inclosing a tapered sleeve split in three or four places, which sleeve is fitted with false jaws held in place by screws. These jaws are made of various diameters. The latest collet-chuck is shown by Figs. 9 to 11; it has adjustable jaws, made in two parts to hold work of any size from 5/8 inch in diameter up to 8 inches in diameter. *A* is the body, *B* the tapering split sleeve, *C* the false jaws, *D* the adjustable jaws.

Three methods are employed in chucking gears. The usual one is that in which the gears are held by the tops of the teeth, as in Fig. 12, *a*, *a*, *a*. The objection to this is the possible want of truth in the teeth, due to inaccurate cutting or to distortion in hardening. Another is that of centering by three rolls or pieces *a*, *a*, *a*, fitting between the teeth at the pitch circle, as in Figs. 13 and 14, adopted very much in consequence of the practice of hardening teeth. The objection to this is the inaccuracy developed by hardening, by reason of which one roll may fit too tightly and another too freely, since tooth spacings and pitchings and the pitchings of blocks of teeth may vary slightly. Fig. 15 shows an improvement in this method; two pins with self-adjusting ends are substituted for a single rigid one. The third method is that by root contact, in which the jaws make contact with the roots of the teeth. This is not open to either of the foregoing objections, since if the gear is not true on the tops of the teeth or at the pitch line, it is set by the roots, from which, as a base, corrections may be made. The contact of pins in the roots may be that of single pins, or two or three in adjacent tooth spaces. Adjustment can be made by securing the pins in a plate with a slot hole as in Fig. 16. This is necessary when the teeth do not occur in multiples of three, in which case the slot hole is a necessity. The slot must be a curved one, as shown, to maintain the radial distance of the pins correct. Figs. 17 and 18 show the chucking of bevel-gears by the root contact. Here the jaws of the collet have their contact faces made on a bevel to fit the roots of the gear. By making the outer edges of the jaws as shown at *a*, they will prevent the gear from slipping out on the closing of the collet.

Figs. 19 and 20 illustrate the method adopted for chucking the large bevel-gears in quantity as used in automobile work. An unhardened gear is sunk slightly into the face-plate *B*, and secured with screws. The gear *C* to be ground is set with its face to the unhardened

gear, and held by three clamps D. In the illustration the face portions of the teeth of the chucking-gear are seen cut away, leaving teeth of full length at only three parts of the circumference, on which the gear to be ground will be supported without rocking, and the hole can be ground truly.

The chucking of bushes or sleeves should be varied according to whether they are thick or thin. There is no risk of distortion in gripping a thick bush as there is in thin ones. Unless sleeves are very long, they are gripped commonly in three jaw-chucks. For long bushes the method shown in Fig. 21 is adopted. Here a special chuck A is screwed to the spindle-nose. It receives a collar B at the rear with a bevelled edge, and another C screwed on the nose, also having a bevelled edge. Between these edges the bush is centered and gripped by the screwing up of the front collar C.

For very thin bushes the endlong grip is retained, as in Fig. 21, but strictly in an axial direction, and with a larger range of capacity to suit bushes of different lengths. Here a cylindrical chuck A (Fig. 22) is screwed to the spindle-nose, having a cap B screwed to fit over the front end. The interior of the chuck is threaded to receive a collar C, which can be adjusted along anywhere to suit the lengths of different bushes within the range of capacity of the chuck. The cap B and collar C are each fitted with plates D and E, interchangeable with holes slightly larger than the hole to be ground, so that for bushings of different bores plates have to be substituted with holes of different sizes. The bush to be ground is thus gripped endwise. It has to be centered before grinding, which is done by a centering plug F of triangular section, which centers the bushing by the holes in the gripping plates D and E. The triangular shape is imparted to F in order that the plug may enter and center a hole which is not quite circular. Afterward the bushings can be mounted on an arbor for grinding the outside.

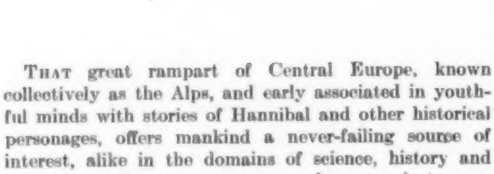
We have here presented an account of only a very small selection of the machines exhibited at Olympia. We may have occasion in later issues to return to this subject and give our readers some further examples gathered from the very fine display of the most advanced practise in machine design offered to the visitor at the international exhibition in the British capital.

A Rampart of Nations*

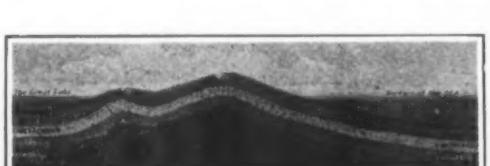
How the Alps Rose from the Sea

THAT great rampart of Central Europe, known collectively as the Alps, and early associated in youthful minds with stories of Hannibal and other historical personages, offers mankind a never-failing source of interest, alike in the domains of science, history and recreation. Our present purpose, however, is to consider very simply, and in the tranquillity of an easy chair, the very simple question: How came the Alps there?

Visitors to the upland valleys of green pasture which gave the Alps their name, will have noted those towering white and light-colored strata that soar upward for many thousands of feet on either hand. A close examination of them will reveal the remains of marine organisms in multitudes. Some are objects which, judging by appearances, might be regarded as prehistoric cousins to the whelk and cockle. Others are lumps of coral, often parts of gigantic reefs, and others again are so minute that they are only revealed by the microscope or by polishing the stone. Indeed, the observer, gazing up at those great precipices of limestone, for such they are, in, say, the Bernese Oberland or the Savoy, is thus made to realize that he is gazing from a point of vantage upon what was, in comparatively recent geological times, more than a mile below the surface of the Mediterranean Sea of those days. A reference to the adjoining, much-simplified diagrams will make this clear; the observer supposing himself placed at the point A in each picture. It is thus possible to see at a glance the combined building-up and denuding processes, together with the general upheaval of the mass, which have taken place during what is known as the Tertiary period. In times long anterior to that a range of mountains composed of Palæozoic strata occupied the site of the Alps; but, in subsequent ages, which can only be vaguely expressed in many millions of years, these mountains were denuded almost to obliteration, and the *débris* washed down and deposited in a shallow sea. There, as the Triassic formation, it formed a sedimentary grave for the life of those days, huge amphibian reptiles and many grotesque and astonishing creatures, saurians of unprepossessing appearance, suggesting something between giant toads and giant crocodiles.



Ideal section illustrating the physical conditions obtaining towards the close of the Eocene period, when the sea-bed, which was eventually to culminate in the Alps, had begun to rise. The strata of rock are practically parallel and, as yet, nearly horizontal.



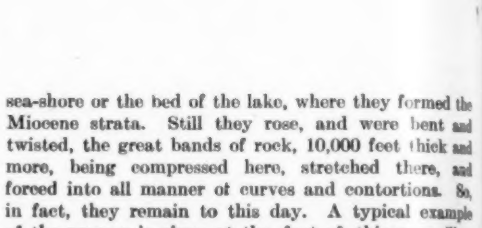
The same region at the close of the succeeding (Oligocene) period and in the early Miocene, when the Alps had risen to a considerable height above the sea-level, and the elements had begun their work of erosion. Note part of the great lake that then covered most of Switzerland.

We have thus the rough foundation upon which the material, subsequently to become the Alps, was laid. This material is shown in the first diagram in layers of geometrical parallelism for clearness. The whole of this area would appear to have gradually sunk into the bosom of what was then a shallow sea, the adjacent lands wearing away. At the time coral reefs abounded in those tropical lagoons, and dinosaurs, huge land reptiles fifty to a hundred feet long, roamed amid the swamps and marshes of a vanishing continent, which was forming, instead, a great bed, thousands of feet thick, on the floor of that Jurassic sea. Still lower sank the land beneath the sea, and new conditions brought about the Cretaceous formation. The giant dinosaurs grew scarce, and eventually died out as the land receded northward. Small marine organisms, foraminifera, sponges, etc., entered largely into the composition of the Cretaceous limestones; and the condition of an ocean prevailed for long ages, while these microscopic organisms then laid down a thousand feet or so of Cretaceous strata. After that came the reaction. The depths began to ascend, the seas became shallower, and a habitat of different organisms was produced. Rivers again brought down *débris*, and the Eocene formation came into existence. We now reach the age of mammals and comparatively recent geological times.

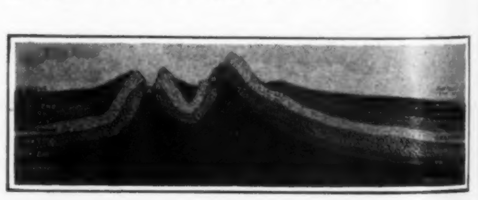
About the close of this period the Alps appeared above the sea; it might be supposed, judging by their present ragged and tumbled-about appearance, that they came in some great convulsion of nature, with an appropriate setting of earthquake, thunder and lightning. One might even think that they were erupted, blown up in a sort of Mont Pelée or Krakatoa cataclysm; but there is not the least reason for supposing that the rising of the Alps was anything remarkable as a spectacle, or even that the occurrence was in any way perceptible, any more than the reported sinking of Gibraltar into the sea is noticeable at the present day, or indeed the rising and falling of local coast lines. Supposing, for instance, that the Oligocene period, during which there is reason to believe a great portion of the Alps was uplifted, occupied, say, 600,000 years, which is a reasonable conjecture, we find that to attain the level of Mont Blanc, some 15,000 feet, the ground needs to rise on an average but two and a half feet a century.

In the second and third diagrams the process is continued: The gradual rise in Oligocene times, when the greater part of Switzerland was a huge fresh-water lake, with the Rigi forming part of its bed. Denudation had begun its work, indicated by the notches B, the escarpment of a rivulet broadened into a valley, and the mountain torrent became a stream. Thus were carried the mud and sand and ground-up fossils of the earlier strata down to the lowlands, the receding sea-shore or the bed of the lake, where they formed the Miocene strata. Still they rose, and were bent and twisted, the great bands of rock, 10,000 feet thick and more, being compressed here, stretched there, and forced into all manner of curves and contortions. So, in fact, they remain to this day. A typical example of the process is given at the foot of this page, illustrating a section extending through the Alps from the Rigi southward, as constructed after the researches of Prof. Heim.

The third and fourth diagrams illustrate how denudation continued its work, as the heights were uplifted during Miocene times, and possibly the later Pliocene. Then came the Glacial Period, which helped materially, according to some geologists, to form the worn contour shown in the fourth diagram. This approximates to modern conditions, and makes clear that the elements will eventually succeed in obliterating the Alps once more, so that ages hence an undulating moorland, capped with an occasional mass of Archæan rock, will be all that remains of the historic rampart to which the civilization of the West owes so much.



Here, at the close of the Miocene period, the Alps had attained great elevation, and acquired the contortions and convolutions observable at the present time. Note the progress of erosion, the receding sea, and the shallowing lake, which, later on, became a famous dwelling place of early man.



Conditions approximating to the present day are indicated here. The elements—rain, frost and the grinding glacier—have greatly altered the appearance of the mountains, and the lake has shrunk to a mere fragment. Note the crystalline core of Palæozoic strata exposed by erosion.

To those who would go deeply into the evidence for the events described in simple fashion above, the new and comprehensive work of Prof. Bonney, entitled "The Building of the Alps" (Unwin), will be of interest, dealing as it does at length with details based upon personal observation.

Ideal section through the Alps from the Rigi southward. After Heim.

* Reproduced from *The Graphic*.

The Physical Testing of Rock for Road Building—II*

The Methods Used and the Results Obtained

By Albert T. Goldbeck and Frank H. Jackson, Jr.

Concluded from Scientific American Supplement No. 1923, Page 298, November 9, 1912

CEMENTING VALUE.

The binding power or cementing value of a road material is the property possessed by rock dust or other finely divided material to act as a cement on the coarser fragments composing crushed stone or gravel roads. "This property varies enormously, not only with different kinds of rocks, but also with those which are practically identical in classification and chemical composition. The absence of cementing power is so pronounced in some varieties of rock that they can never be made to compact with the road roller or under traffic. As the binder surface of a macadam or gravel road is most exposed to the action of wind and rain as well as the wear and tear of traffic, it can be seen that the presence of this property is most essential to good results. Further than this, the hardness and toughness of the binder surface, more than of the rock itself, constitute the hardness and toughness of the road, for if a load be sufficient to destroy the bond of cementation of the upper surface of the road, the stones below are soon loosened and forced out of place. The impervious shell obtained by the use of a rock of high cementing value gives the greatest protection to the foundation of a road. Moreover, it is a matter of common observation that a good surface which binds well is less dusty and less muddy, while the advantage from the standpoint of economy is very great, as it is only the loose, unbound material which is ordinarily carried away by wind and water."

Investigations in the U. S. Bureau of Chemistry indicate that the cementing value depends on certain hydrated colloid conditions of the particles.[3] "All rock powders that cement well are hydrated, i. e., contain water of combination, although it does not follow that all hydrated rock powders will cement. It seems that only a certain kind of water of combination is concerned with and measures the cementing value. This property is undoubtedly related to that of plasticity in clays and, in a few words, is due to the amorphous inorganic particles, which by reason of their characteristic porous structure are able to absorb and hold water, thereupon assuming a plastic and coherent condition."

*Department of Agriculture, Office of Public Roads, Bulletin 44.

[3] U. S. Department of Agriculture, Bureau of Chemistry, Bulletin 79.

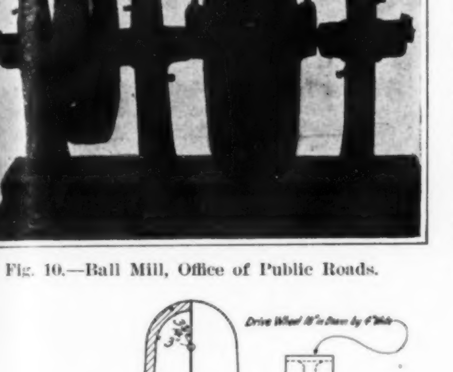


Fig. 10.—Ball Mill, Office of Public Roads.

Ball Mill.

The following method for testing the cementing value of rock powders was devised and perfected by Mr. Logan Waller Page. One half kilogramme of the rock to be tested is broken sufficiently small to pass a half-inch mesh screen. This material is placed in a ball mill with about 90 cubic centimeters of water sufficient to make a stiff paste after grinding. The mill, shown in Figs. 10 and 11, consists of a cast-iron casting *A-B* split into two unequal segments *A* and *B*. It revolves in a vertical plane about the shaft *CC*, which bears in the pillow blocks *DD* and is driven from the pulley *E*.

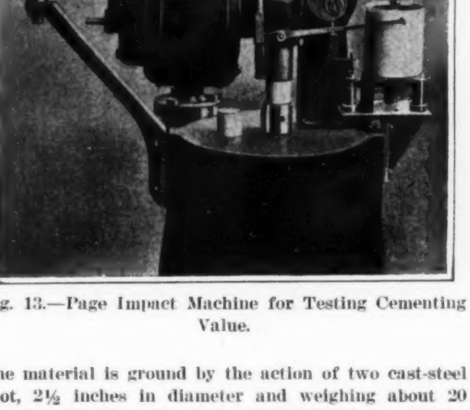


Fig. 13.—Page Impact Machine for Testing Cementing Value.

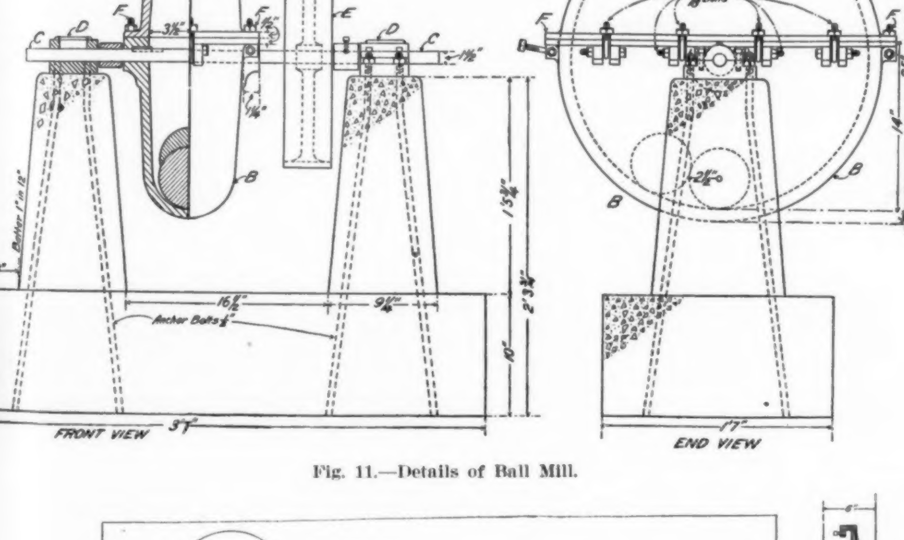


Fig. 11.—Details of Ball Mill.

The material is ground by the action of two cast-steel shot, 2½ inches in diameter and weighing about 20 pounds. Grinding is continued for 2½ hours at the rate of 2,000 revolutions per hour, after which the "dough" is removed and molded into cylindrical briquettes 25 millimeters in diameter and 25 millimeters high in a special briquette-forming machine, shown in Fig. 12.

Briquette Machine.

(For molding rock-dust specimens.)

The hydraulic cylinder *A* (Fig. 12) supports an iron platform *B* through the piston rod *C*. The cylindrical metal die *D* provided with a closely fitting plug *E* sup-

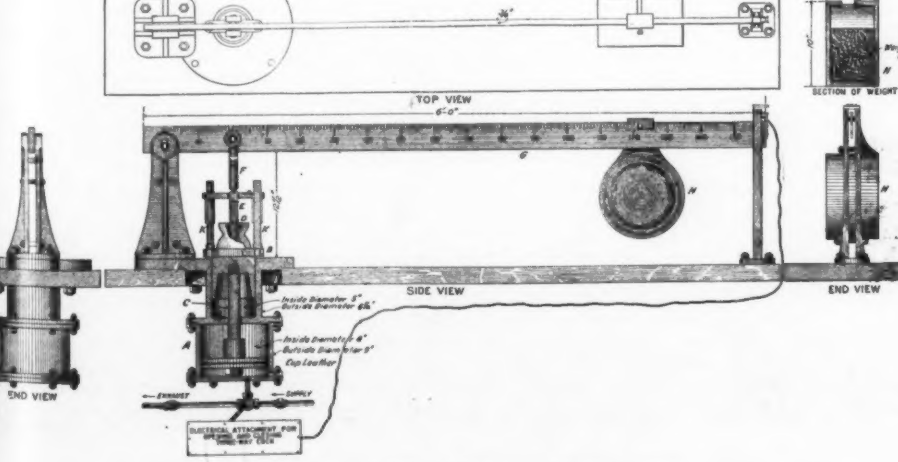


Fig. 12.—Details of Briquette Machine.

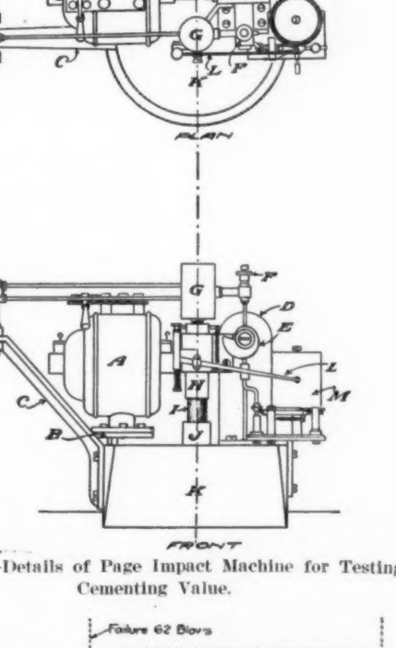


Fig. 14.—Details of Page Impact Machine for Testing Cementing Value.

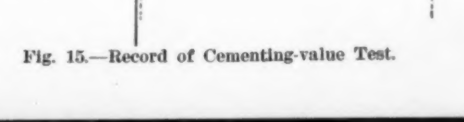


Fig. 15.—Record of Cementing-value Test.

ported by guide rods *KK* and containing the material to be compressed is placed upon the platform and water admitted to the cylinder through the supply pipe. As the piston rises, the platform and die are carried up with it, and the plug of the latter comes in contact with a properly weighted lever arm *G*. The weight *H* is adjusted on the lever arm so as to give a maximum pressure of 132 kilos per square centimeter on the compressed material, but this pressure is applied for only an instant. The total time of compression up to the maximum is about 30 seconds.

The electrical attachment shown is not used at present, as it has been found much more satisfactory to operate the water supply by hand.

Page Impact Machine for Testing Cementing Value.

The motor *A* drives the cam *E* at the rate of 60 revolutions per minute, by means of a worm gear. The hammer *G* is raised by means of the adjustable pin *F*, which slides over the face of the cam. With the plunger *H* resting on the briquette *I*, the end of the pin *F* is brought in contact with the cam as indicated on the drawing (Fig. 14), and the binding nut is tightened to hold the pin in position. The rise of the cam is such as to give an effective drop of one centimeter to the hammer. The reaction of the briquette after each blow of the hammer produces a vertical movement in the end of the lever *L*. This motion is recorded on a sheet of silicated paper wrapped around the recording drum *M*, by means of a brass point at the end of the lever *L*. Each revolution of the cam produces a slight motion of the drum, so that the drum makes a complete revolution in 100 revolutions of the cam. The number of blows necessary to destroy the resilience of the briquette, so that no reaction is recorded on the drum, is taken to be the cement value of the material. (See Fig. 15.)

SPECIFIC GRAVITY.

The specific gravity of the rock for road materials is determined as follows: A small sample of rock weighing from 10 to 12 grammes is weighed in air while held suspended from the balance by a fine silk thread. The specimen is then immersed in water and weighed immediately, but no account is taken of the small error due to the immersed portion of the thread.

Calling Wa the weight in air (in grammes)

Ww the weight in water (in grammes)

$$\text{Then the specific gravity} = \frac{Wa}{Wa - Ww} = G.$$

Weight Per Cubic Foot.

The weight of rock per cubic foot, if solid and not broken into fragments, is obtained by multiplying the specific gravity by the weight of a cubic foot of water, 62.37 pounds.

Absorption.

The absorption is obtained from the same sample of stone that is used for the specific-gravity test. The sample is kept immersed for four days, during which time it attains constant weight. The absorption is expressed in pounds per cubic foot.

Let Wa = weight of specimen in grammes in air;

Ww = weight of specimen in grammes in water just after immersion; and

$W'w$ = weight of specimen in water after immersion for four days.

Then the absorption in pounds per cubic foot =

$$\frac{W'w - Ww}{Wa - Ww} \times 62.37.$$

Test of the Office of Public Roads.

The previously described tests since 1902 have been conducted in the road material laboratory, now of the Office of Public Roads and formerly in the Bureau of Chemistry of the United States Department of Agriculture. These results have been tabulated, and the table following (O. P. R. Form 28) gives the maximum and minimum values obtained on all rock samples tested up to January, 1912.

INTERPRETATION OF RESULTS OF TESTS.

1. *Hardness.*—Rocks having a coefficient of hardness below 14 are called soft; from 14 to 17, medium; and above 17, hard.

2. *Toughness.*—The results of the toughness test are interpreted so that rocks which run below 13 are called low; from 13 to 19, medium; and above 19, high.

3. *Resistance to Wear.*—In interpreting the results of this test, a French coefficient of wear below 8 is called low; from 8 to 13, medium; from 14 to 20, high; and above 20, very high.

4. *Cementing Value.*—Cementing values below 10 are called low; from 10 to 25, fair; from 26 to 75, good; from 76 to 100, very good; and above 100, excellent.

5. *Absorption.*—The absorption test is of value in judging the probable lasting qualities of the rock under the action of frost. The presence of frost in the stones is likely to be promotive of weakness or disintegration and, for this reason, is liable to cause rapid crumbling of the screenings and the wearing surface of the road. The higher the absorption the greater the effect of frost. In bituminous-bound work some observations seem to indicate that it is of advantage to use a rock of high absorption rather than one with low absorptive qualities, since the bituminous material is taken in by the porous rock and binds it together more efficiently than in the case of rocks of low absorption. The indications are that the cushioning effect of the bituminous binder renders the rock in a bituminous-bound road more resistant to wear than in a water-bound macadam, making it possible to use a softer rock than in water-bound construction when subjected to the same traffic conditions.

TABLE 1.—*Maximum and minimum results on rock samples, corrected to Jan. 1, 1912.*

No. of samples.	Name.	Specific gravity.			Weight—pounds per cubic foot.			Water absorbed—pounds per cubic foot.		Per cent of wear.		French coefficient of wear.		Hardness.		Toughness.		Cementing value.	
		Max.	*Min.*	*Av.*	*Max.*	*Min.*	*Av.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Mx.*	*Mn.*	*Max.*	*Mn.*
16	Amphibolite	3.10	2.70	3.00	193	168	187	1.65	0.04	10.3	1.0	41.7	3.9	19.0	13.5	40	7	235	11
63	Andesite	2.95	1.85	2.65	184	115	165	12.50	.06	17.4	1.5	26.0	2.3	19.4	5.0	44	5	500+	9
183	Basalt	3.05	2.30	2.85	190	143	178	6.40	.02	16.6	1.3	30.4	2.4	19.3	5.7	[illegible]	5	500+	2
52	Chert	3.00	2.00	2.55	184	125	159	11.10	.26	29.2	2.7	14.9	1.4	19.7	12.7	25	5	500+	2
9	Conglomerate	2.65	2.00	2.63	165	156	163	3.71	.26	12.7	3.5	11.6	3.2	18.4	9.3	10	10	500+	20
217	Diabase	3.20	2.60	2.96	200	162	185	2.73	.03	6.3	1.1	36.4	6.4	19.4	12.3	54	4	500+	2
73	Diorite	3.35	2.70	2.96	209	168	179	1.03	.05	12.0	1.6	25.0	3.3	19.4	16.6	28	4	148	3
183	Dolomite	3.00	2.30	2.73	181	143	170	9.40	.07	18.6	1.2	33.3	2.2	18.8	1.8	27	3	179	9
6	Eclogite	3.65	2.95	3.20	228	184	200	.28	.10	2.9	1.8	22.7	13.8	18.7	17.4	31	14	130	10
11	Epidosite	3.30	2.70	3.04	206	168	190	1.65	.22	7.4	2.0	19.6	5.4	19.3	10.7	23	8	83	3
11	Felsite	2.80	2.50	2.65	175	156	165	3.13	.02	3.4	1.9	21.3	11.8	.....	.....	.....	.....	.....	.....
91	Fieldstone	.....	.....	.....	.....	.....	.....	.....	.....	10.3	2.1	19.0	3.8	.....	.....	.....	.....	15	13
42	Gabbro	3.65	2.75	2.97	228	172	185	.97	.04	5.9	1.3	30.8	6.8	18.8	13.3	23	8	134	6
152	Gneiss	3.20	2.60	2.75	200	162	172	1.24	.02	16.4	1.7	23.0	2.4	19.3	9.0	25	2	110	1
219	Granite	3.00	2.00	2.66	187	125	166	2.77	.04	24.6	1.1	37.0	1.6	19.6	13.6	33	2	255	2
136	Gravel	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500+	3
718	Limestone	2.85	2.00	2.66	178	125	166	13.22	.02	34.2	1.8	21.7	1.2	19.1	.0	25	2	500	0
37	Marble	2.85	2.65	2.76	178	165	172	2.19	.10	14.0	2.3	17.5	2.8	17.3	7.1	23	3	85	10
9	Marl	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	500+	96
19	Mixed stone	.....	.....	.....	.....	.....	.....	.....	.....	10.3	2.1	19.1	3.9	.....	.....	.....	.....	.....	.....
5	Peridotite	3.55	2.65	2.95	221	165	184	1.02	.27	5.3	3.0	13.2	7.6	15.0	13.3	12	9	91	25
90	Quartzite	3.15	2.35	2.67	196	147	167	2.95	.05	7.6	1.6	24.5	5.3	19.7	15.3	30	5	45	0
42	Rhyolite	2.90	2.05	2.56	181	128	160	7.15	.03	9.7	1.7	23.0	4.1	19.7	15.3	42	6	500+	9
340	Sandstone	3.25	2.00	2.61	203	125	162	11.60	.02	41.7	1.0	40.8	1.0	19.5	.0	60	2	500+	1
136	Schist	3.20	2.65	2.94	200	165	183	1.36	.06	23.3	1.3	31.7	1.7	19.0	.9	44	3	232	5
9	Shale	2.70	2.50	2.65	168	156	165	4.84	.50	16.2	3.2	12.6	2.5	17.7	13.9	12	3	367	20
55	Slag	3.90	2.00	2.97	243	125	185	4.40	.04	13.5	2.5	15.7	3.0	18.3	10.7	21	2	500+	1
59	Slate	3.35	2.60	2.78	209	162	173	2.10	.05	12.4	1.6	24.4	3.2	19.7	1.1	56	1	500+	1
27	Syenite	3.05	2.15	2.65	190	134	165	4.21	.06	14.4	1.6	26.6	2.8	19.2	17.3	34	8	375	10

The ideal rock for the construction of a macadam road is one which resists the wear of the traffic to which it is subjected to such an extent as to supply just a sufficient amount of binding material to cement the road. If, after the road is constructed, the traffic is not sufficiently severe to wear off the requisite amount of binder to replace that carried away by wind and rain, the road "ravels." Should an excess amount of fine material be worn away, the road becomes muddy and dusty. In either case the rock was not suited for the road on which it was used. A softer rock should have been used in the first case and a harder, tougher rock in the last case.

In the case of a very lightly-traveled road or parkway, the best results could be obtained, not with a hard, tough rock, but with a softer material with a good cementing value. Under the conditions to which this type of road is ordinarily subjected, a hard tough rock would build a road likely to ravel because of the lack of binding material supplied by traffic, whereas if a softer material were used, sufficient binder would result from the wear produced by traffic.

For the construction of heavily-traveled roads, a very hard, tough rock with good cementing value is necessary.

The following facts should be taken into consideration before attempting to interpret the results of the laboratory tests on samples of rock intended for use in macadam road construction, viz: 1. The character of its traffic to which the material is liable to be subjected, whether (*a*) automobile, or (*b*) horse-drawn—and if so, whether (1) heavy, (2) medium, or (3) light. 2. The character of the material under examination, that is, (*a*) its name, and (*b*) its approximate mineral composition and structure. 3. The behavior of material of a similar nature in actual service.

1. *Character of Traffic.*—The following discussion will apply only to materials which are to be subjected principally to horse-drawn traffic, as ordinary macadam roads have been found impracticable when much automobile traffic exists. For a discussion of the bituminous and other binders, which should be used in such cases, reference may be had to other publications of this office.[4] Assuming the traffic to be principally horse drawn, it is necessary to know whether it will be heavy, as in the vicinity of the large cities; medium, as on the principal country highways; or light, as on park or the less important country roads. It has been found by experience that certain rocks, such as the hard, tough traps, are no more suitable for use on park roads than are the softer limestones for the main arteries of a large city.

2. *Character of material.*—It is of value to know the name and character of the material under discussion in order that an intelligent comparison may be made with similar materials in actual service.

3. *Behavior of Similar Rock in Service.*—No matter how carefully conducted, it is impossible for laboratory tests to do more than approximate the conditions of actual traffic. It would, therefore, be impossible to judge accurately the qualities of a road material from laboratory tests alone, unless supplemented by the experience obtained by observation of similar material in service.

The various rock types commonly used in road construction will be considered in order; the relation between the laboratory tests and the results obtained in practice as determined by observation will be shown and the particular class of traffic to which the rock is best adapted will be indicated. Experience has shown that, in general, the following table of limiting values for laboratory tests may be used in determining a sample's fitness for use on roads, if taken in connection with the conclusion drawn below under each heading.

TABLE 2.—*Limiting Values.*

Character of Traffic.	RESULTS OF TESTS: Per Cent of Wear.	Hardness.	Toughness.
Heavy	2.5 or less	18 or over	19 or over
Medium	2.5 to 5	14 to 18	14 to 19
Light	5 to 8	10 to 14	8 to 14

The cementing value should in general run above 25 for all classes of traffic, except in specific cases, as noted below.

Trap.

The traps, including the usual varieties of diabase, basalt, andesite, gabbro, etc., on account of their high resistance to wear, hardness, and toughness are particularly well adapted for roads subjected to heavy teaming. They also bind well on the road, provided the traffic is heavy enough to supply by wear enough fine material to replace that lost by natural causes. The low cementing value sometimes found is apparently not borne out in practice, since these rocks bind well on the road. Otherwise, the laboratory tests appear to agree quite closely with the results in practice, and Table No. 2 may, therefore, be applied quite rigidly to this class of material.

Limestone and Dolomite.

Low resistance to wear and a good binding value, which are the distinguishing characteristics of the limestones, are usually shown quite plainly from the results of laboratory tests. The results of laboratory tests may, therefore, be taken as a very fair indication of the probable behavior of the material in service, and Table No. 2 may be applied with comparative closeness.

Granites.

Lack of toughness and binding power renders the granites, as a class, unfit for use in any but the foundation courses of macadam roads. The laboratory test will usually show these defects, except in the case of highly altered material, which will invariably show a good cementing value in the laboratory. Experience has shown, however, that even such material should not be used for surfacing on account of the ease with which it distintegrates under traffic.

Sandstones.

The laboratory tests do not agree concerning sandstones as closely as they should with the results in practice. This is especially true in their wearing and binding qualities, for, although these tests quite frequently run high in the laboratory, it is undoubtedly true that, except in some instances, material of this nature is unsuitable for use except in the foundation courses. As a rule, therefore, it is necessary, in judging this material, only to determine whether it has sufficient strength to stand up under the roller.

Chert.

Chert is a very hard material and usually shows good resistance to wear and rather low cementing value in the laboratory. It has been found, however, that it, in general, develops good binding qualities on the road.

Gneiss, Schist, and Slate.

Owing to their foliated structure, gneiss, schist, or slate should never be used in road construction when a better material is available.

Marble and Quartzite.

Neither marble nor quartzite is of much value to the road builder for the wearing courses of macadam roads, the first on account of the crystalline structure and the second on account of its extreme hardness and lack of binding power.

[4] O. P. R. Bull. 34, 38; circulars 47, 89, 90, 92, 94, 96, 97.

Cosmical Problems*

Their Influence on the Development of Spectrum Analysis

By Prof. Wolf-Königstuhl

The present development of spectrum analysis could not have taken place without its application to cosmical problems, from which it originally sprung and upon which it has grown great. When Wollaston substituted the narrow slit for the round hole he was interested in the question whether any colors were lacking in the solar spectrum. When Fraunhofer studied the lines which bear his name he was thinking not of practical problems alone, but of the significance of these remarkable lines and why the moon gives the same lines as the sun, while the stars give different lines. The last named fact convinced him that the cause of most of the solar lines lies in the sun and not in our atmosphere.

The discovery of the coincidence of the dark solar lines with the bright lines of laboratory flames suggested the researches of Swan, Miller, Stokes, William Thomson, Foucault, Angstrom, and Baulfour Stewart, which explained the reversal of the lines, and those of Bunsen and Kirchhoff by which the explanation was completed and the reversal effected in the laboratory. Bunsen's researches furnished the foundation of Kirchhoff's law, that each element absorbs the same waves that it emits, a law that enables us to recognize terrestrial elements in the sun and stars. Then began the long laborious and still unfinished series of exact measurements of the lines of the elements and those of the solar spectrum.

The question, which solar lines originate in the sun, and which are added by our atmosphere, was studied by means of comparisons of spectra, accurate analyses of the air, differential measurements interpreted by Doppler's principle, and observations at high altitudes. Doppler's principle, which enables us to deduce the movement of a source of light from the change in wave length, owes its development to its application to the sun and stars. This principle has revealed to us the constitution and extent of the milky way, and has given us glimpses of the intimate structure of matter.

The periodic arrangement of lines in the spectral elements has been studied mainly in connection with astronomical researches. In this connection the discovery of the second series of hydrogen lines in stellar spectra should be mentioned. The determinations of the temperatures of the sun and stars, formulæ of radiation, the researches on the spectra of carbon compounds suggested by the observation of comets, and the first successful quantitative analyses which owe their origin to Lockyer's spectroscopic studies of sun spots are a few of the striking results achieved in the study of cosmical problems.

The mapping of the solar protuberances and other features of the sun is a still more striking example. These protuberances were first observed only in total eclipses. The spectroscope was first applied to the protuberances in the eclipse of 1868. A spectrum of very bright lines, coinciding with the hydrogen lines, was observed. The protuberances, therefore, must be masses of incandescent gas rising high above the solar surface. This fact suggested to Janssen the possibility of observing the spectrum of the protuberances without the aid of an eclipse. The protuberances are ordinarily made invisible by the intense illumination of the terrestrial atmosphere around the sun's image. In a spectroscope of great dispersion this white light is spread out and weakened without sensibly diminishing the monochromatic light of the protuberances. In 1868 Janssen succeeded in observing the protuberance spectrum at the edge of the sun, and the same result was obtained almost simultaneously by Lockyer.

By moving the slit of the spectroscope over the telescopic image of the sun's edge the height and extent of the protuberances could be determined from the variation in the length of the lines. Soon Huggins succeeded, by the use of an absorbing medium, in seeing the entire protuberances through a widely opened slit, while Zoellner and Lockyer obtained the same result by increasing the dispersion, just as one can see the whole form of a sodium flame through a train of prisms without a slit.

It was discovered that the protuberances sometimes resembled vast flames and sometimes clouds floating over the apparent edge of the sun. The spectrum varies greatly at different times and different parts. Now appear the bright hydrogen and calcium lines, sometimes with the addition of the lines of helium and again the lines of iron and other metals are seen. In general the spectrum depends upon the stability of the protuberance becoming more complex with increasing motion of the latter. A bright line near the sodium lines especially interested Lockyer because it sometimes failed to share the displacement which the movement of the protuberance impressed upon the hydrogen and calcium lines in accordance with Doppler's principle. He ascribed this line to an unknown element which he called helium and which remained an astronomical tradition from 1870 until 1895, when Ramsey extracted it from the mineral cleveite.

Although direct visual measurement and spectroscopic observation gave, in general, according values for the velocity of the eruptive protuberances, the displacement of the lines often indicated on Doppler's principle velocities so great that they appeared impossible. Julius attempted to explain the displacement by anomalous dispersion.

For many years attempts were made in vain to photograph the protuberances, and the first photographs obtained were very poor. The correct idea was expressed by Braun, but had been forgotten. Hale of Chicago and Deslandres of Paris attained the goal by slightly different paths. Hale's spectroheliograph is a remarkably fruitful invention and apparently a very simple one, yet its development to practical utility involved immense labor.

The telescope produces a large image of the sun's disk in the plane of a spectroscope slit which admits a narrow strip of the image. The light of this strip is extended into a spectrum and falls upon a second narrow slit placed immediately over a photographic plate. The second slit is placed in the position of one of the protuberance lines, so that only the light of the protuberances can fall upon the plate. Now the apparatus is set in motion. The first slit moves slowly over the edge of the sun and the second slit moves with corresponding velocity over the photographic plate. The result is that the protuberance is photographed by the light of one of its lines.

By this process it is possible to photograph monochromatically not only the protuberances and the edge of the sun, but the entire solar disk. Theoretically any line of the spectrum, even a dark absorption line, can be used. Indeed, any part of a line may be employed and thus, according to the theory of the influence of pressure upon the form of the lines, it is possible to explore the sun at various levels. Finally, Deslandres has succeeded in applying Doppler's principle to the study of the motion of every part of the sun.

The lines most suitable for use are the lines *H* and *K*, which are now ascribed to calcium. In the general solar spectrum these lines are very broad, dark absorption bands, while they appear as bright lines in spectrum of the protuberances.

The bright calcium lines are found almost everywhere on the solar disk. In many places they yield photographs of large cloud-like masses; they are especially strong near the sun spots and faculæ. From Kirchhoff's law and laboratory experiments it is assumed that the width of a spectral line increases with the density of the incandescent gas which produces it. This applies also to absorption lines. Hence, it is inferred that the very wide calcium bands *H* and *K* are produced by masses of calcium vapor at great depth and high pressure. In the middle of the wide absorption band lies a relatively bright line which, however, is considerably fainter than the continuous spectrum of the sun, and in the middle of this bright line is a very fine dark line. This fine dark line is attributed to the least dense, highest and coolest calcium vapor; the broad dark band to the deepest, hottest and most dense; and the intermediate line to vapor of intermediate position, temperature and density. The calcium clouds of these three levels can be photographed separately by setting the second slit of the spectroheliograph, successively, upon the three parts of the *K* line. This result was first obtained by Hale, Deslandres has recently obtained analogous results with the hydrogen line.

The dark Fraunhofer lines, especially the iron lines, have also been employed. These lines appear dark by contrast. Their intensity is weakened by absorption, but they are really thousands of times brighter than the light of the full moon and as bright as the glowing vapor which produces the absorption. Hence, any of these so-called dark lines will produce an image in the heliospectrograph if the exposure is sufficiently long. The slightest variation in brightness, from point to point of the line is represented, and thus the distribution of these absorbing clouds over the sun's disk can be charted. By using different parts of a line, various levels can be mapped. By using lines peculiar to one solar stratum, such as the chromosphere or the reversing layer, the distribution of this stratum can be studied. In this way the four distinct strata have been mapped out, both in hydrogen and in calcium. The brightest parts of the sun lie above the visible faculæ. The darkest part are variously distributed over the surface and through the deepest layers. In the sun spots they lie very deep.

The discussion of this material has produced a fruitful theoretical controversy. According to Jewell, the principal lines of the solar spectrum resemble those of calcium and hydrogen in structure, and the problem is to determine how far this structure is due to variations in pressure and temperature, according to Kirchhoff's law, and whether it is to be explained by Doppler's principle, or by anomalous dispersion. When white light passes through masses of incandescent vapor of varying density, it is extended into a spectrum which is irregular and discontinuous. The absorption lines are displaced and distorted because the dispersion for these wave lengths varies discontinuously. If this spectrum is viewed through a spectroscope whose dispersion is at right angles to its own, it appears sharply broken at the wave lengths peculiar to the gas, and shows narrow bright lines at the bends and broad lines elsewhere. This suggests that the dark lines may be broadened or reversed by refraction at points of the sun's disk by overlying masses of gas. This possible effect of anomalous dispersion casts doubt upon the conclusions of Hale and Deslandres, and make it questionable whether the spectroheliograph depicts the real contour of glowing masses of gas, or represents only the effect of varying density.

Anomalous dispersion varies greatly with wave length and the images of the protuberances, if due to this cause, should vary accordingly; but the protuberances at the sun's edge are shown in the same dimensions by every line of hydrogen and calcium. The anomalous dispersion in the sun may be much greater than in the laboratory, as Julius suggests.

Another argument against the admission of anomalous dispersion as a principal factor is the uniform system of distribution of gases at different levels, which is shown by all the lines of hydrogen and calcium and many other lines. Additional evidence is furnished by the perfect meteorological system of atmospheric currents deduced from the Doppler principle. In general, the luminous gases rise in the equatorial zone and the absorbing gases sink. The spectroheliographic pictures given by every spectral line also show precisely the perspective foreshortening of the clouds which their geometrical positions on the globe of the sun demand, while they can be explained by anomalous dispersion only when they appear in the center of the disk.

The intense circulation of gases shown by Deslandres' ingenious velocity recorder is also unfavorable to the anomalous dispersion hypothesis. This velocity recorder is a spectroheliograph in which the two slits move not continuously but step by step, producing a series of instantaneous views of successive portions of the disk, so that the local distortions of the lines can be studied. Such series made with the innermost part of the *K* line indicate great and regular movements of the gaseous masses, and can hardly be explained by the slight anomalous dispersion which can occur at this point.

Especially interesting are the movements of the great dark bands, called filaments, which surround the pole like circles of latitude. These bands are invisible to the eye and are revealed only by the narrow, dark, inner part of the spectral lines, as dark masses of gas at great altitude. They always exhibit the same movements and according to Doppler's principle represent the zones in which the gases rise in all longitudes, in contrast to the equatorial zones of spots and faculæ where the general motion is downward.

A great variability in the lines of the same element in sun spot spectra was first discovered by Lockyer, and the discovery has been confirmed by recent observations at Mt. Wilson. The simplest explanation is given by anomalous dispersion, if we assume that this is effective near the particular lines of iron or titanium that are displaced, distorted, widened or reversed; but in order to make this explanation convincing the anomalous dispersion of the gases present must be tested for every wave length in question. Lockyer explained the phenomenon by atomic decomposition.

* An abridgement of an address made before the German Bunsen Society, and published in the *Zeitschrift für Elektrochemie*.

Another plausible explanation is given by Lenard's discovery that the same element emits different lines in different parts of the flaming arc.

The spectra of the sun spots are exceedingly complex and puzzling. They show widening of most, but not all, absorption bands, distortion of many lines, the presence of lines peculiar to the sun spots, bright reversals in the middle of absorption lines, the absence of familiar lines, the presence of fluted bands, a dependence of the phenomena upon the eleven-year period, and many other peculiarities. Hence, they have suggested many researches conducted with a view of deciding the controversy of anomalous dispersion, versus density and the Doppler effect. Two of the most interesting of these researches are due to the initiative of Hale. In one research the widening of the absorption lines of the sun spot was shown, by experiments on the flaming arc and furnace fires, to be probably due chiefly to lowering of temperature, in contradiction to Lockyer's views and in accordance with those of Bunsen and Kirchhoff. This research also proves that many of the puzzling bands are due to the formation of titanium oxide. These bands had previously been studied carefully by Vogel, in consequence of their appearance in the spectra of some stars, and had been identified in the laboratory by Fowler. The same physicist subsequently traced the sun spot bands in the green to magnesium hydride, and Olmsted proved that some bands in the red were produced by calcium hydride.

The second research was concerned with the fact that many of the greatly widened absorption lines show bright lines at their centers. We have already seen that Julius attempted to explain this phenomena by anomalous dispersion. Hale's spectroheliographic research indicates a cyclonic motion in the sun spots and suggests a circulation of ionized gases, which produce a magnetic field.

Zeeman discovered in 1896 that the wave length of light is influenced by a magnetic field, owing, it is conjectured, to a change in the vibrations of the electrons. It was shown that both bright and dark lines traversing a magnetic field are separated into components polarized in different ways. The two limiting cases are of especial interest. When the direction of a ray is parallel to the magnetic lines of force, the line is split into two widely separated components, which are circularly polarized in opposite directions. This is called the longitudinal Zeeman effect. When the ray is perpendicular to the magnetic force, each spectral line is separated into three lines, lying near together, and each of these lines is plane polarized, the middle line in the plane at right angles to the common plane of the others. The middle line is usually very weak. This is the transversal Zeeman effect. The longitudinal effect is produced in a sun spot at the center of the sun's disk where the rays which reach the earth are parallel to the axis of the cyclone, while the transverse effect is observed in spots at the edge of the disk, where the rays are nearly perpendicular to the axis.

In both cases Hale has obtained spectroheliographic pictures showing precisely the phenomena of separation and polarization that the Zeeman effect demands. Hence, it cannot be doubted that the abnormal widening of many lines in the sun spot spectra and the apparent central reversals are due to the Zeeman effect of a circulation of electrified particles around the spot, and not to anomalous dispersion.

The application of the spectroscope to other heavenly bodies than the sun has also contributed greatly to the development of spectrum analysis. Two examples will be briefly mentioned. In the outburst of a new star the light emitted often increases 25,000 times in a few hours. In the case of Nova Persei (1901) the light was so intense that the gradual illumination of the cosmical dust in the neighboring part of the sky could be observed. The spectral phenomena shown by these bodies are very striking. As a rule, a very bright continuous spectrum, with its absorption lines, especially those of calcium, very sharply defined, is first observed. Soon bright lines appear bordering the most striking of these absorption lines on the side toward the red end of the spectrum. Every hydrogen line is thus bordered. The bright lines rapidly widen and cover the dark lines, while the continuous spectrum gradually grows fainter. Then periodical phenomena are observed. The lines regularly expand and contract in a period of a few days, and exhibit a very complex structure. Each curve of their variation shows a principal maximum and several secondary maxima. Meanwhile the total brightness of the star fluctuates.

As both the absorption lines and the maxima of bright lines are often greatly shifted, the first explanation thought of was based on movement and Doppler's principle. In this way, incredible and continuously varying velocities, often exceeding 1,000 kilometers (621 miles) per second were deduced. Furthermore, very different velocities were found in different parts of the spectrum. Hence, this explanation was soon abandoned and help was sought in the laboratory.

Among the researches thus suggested were Wilsing's application of Lommell's theory of the damping of vibrations by pressure; Humphrey's and Mohler's proof of the influence of increased pressure on the displacement of lines, and Wilsing's demonstration of the increase of pressure by the generation of electric sparks beneath liquid surfaces. It has been established that increased pressure displaces emission lines toward the red, and widens them, to an extent which varies for different elements and different wave lengths. Hence, it seems probable that the birth of a new star is accompanied by immense and periodically fluctuating pressures produced by tidal action, and that the radiation from the external and internal parts alternately preponderates. The nature and cause of the process, however, are not yet known. When a hydrogen line comprising a dozen oscillating maxima shall have been produced in the laboratory as it is produced in the new stars, we shall know more about these bodies, and also about the structure of atoms.

The other example is that of the very faint nebulæ which long constituted the most barren field of cosmical spectrum analysis. In order to obtain photographs of their spectra, it is still necessary to employ an exposure of 30 or 40 hours, which involves weeks of arduous labor.

Soon after the application of spectrum analysis to the nebulæ, Huggins succeeded in proving that these objects are of two distinct types, the one showing bright line spectra, the other continuous spectra like the sun's. The nebulæ of the first class, therefore, are gases and those of the second are star clusters. Little further progress was made for many years, but gradually the wave lengths of many bright lines of the gaseous nebulæ were determined. These spectra contain the lines of hydrogen and helium, and also several other lines which cannot be produced in the laboratory. Those of the unknown lines which occur in all nebulæ were attributed to an unknown element, nebulium, as certain solar lines had been ascribed to the unknown helium and the still unknown coronium, both of which are represented also in the spectra of the nebulæ.

Many attempts have been made to find nebulium in the laboratory, and the hydrogen lines of the nebulæ have also been studied diligently. The relative intensity of these lines differs from that of the hydrogen lines produced in the laboratory. In the nebulæ the brightest hydrogen line is the second, in the laboratory it is the first. In seeking an explanation for this anomaly, Lockyer has endeavored to restrict the hydrogen spectrum to the second line by diminishing the thickness of the luminous stratum in accordance with the Kirchhoff-Zoellner law. On the other hand Scheiner's experiments appear to indicate a physiological cause for the apparent difference in the two spectra.

It has also been found that in large nebulæ the intensity of certain lines varies from place to place. From this fact conclusions have been drawn in regard to the distribution of matter in the nebulæ, and in a similar manner conceptions of the nature of the unknown elements have been formed. Individual lines which have been attributed to the same unknown element behave differently in the spectra of different nebulæ. The form of the ring nebula in Lyra, when photographed through prisms without a slit, shows that some of the lines originate in its interior and others in its exterior parts. The same result is shown by a spectrum photograph taken with a slit.

J. W. Nicholson first attempted to compute the periods of vibration of the hypothetical element nebulium, which he pictured as the simplest conceivable atom, composed of various numbers of negative electrons revolving about one positive electron. The radius of such an atom would be, according to Thomson's theory, about 3.5×10^{-8} centimeter. In this way all except two of the lines which had been ascribed to nebulium were calculated. These two are precisely those lines which are distinguished from the rest in the spectral photographs of the ring nebula. They belong, therefore, to other elements.

Nicholson's calculations indicated the existence of a faint nebulium line which had never been observed, but which has subsequently been found in the spectra of the nebulæ. This discovery of a theoretically computed spectral line supplies a confirmation of the electronic theory similar to that which the discovery of the planet Neptune in its calculated position furnished for the theory of universal gravitation.

To Make Blue Prints Black and White

ALTHOUGH it seldom becomes necessary to make additional prints from a blue print, it is possible to do so, provided the original print first is converted into one in which the lines are black and the background white. The operation to change the color is neither difficult nor does it require a great amount of time. It is merely necessary that the print be immersed in a solution formed of ¼ ounce of ordinary borax dissolved in 6 ounces of cold water. When the print has blackened, it should be removed and washed thoroughly and placed in a solution composed of ¼ ounce of gallic acid, ¼ ounce of tannic acid and 8 ounces of cold water. This will intensify the color and make the print permanent.—*The Concrete Age.*

The Symbiotic Life of Yeast Races.—Symbiosis is a phenomenon well known to the biologists, this term being employed to denote the mode of life characteristic of certain pairs of species, in which each member of the pair is more or less dependent upon the other for its existence. Numerous cases of this kind are known among the higher animals and plants, but Prof. Vandevelde has recently shown that the same kind of effect can be observed in the case of such low organisms as the yeast fungus. He has demonstrated that the joint cultivation of certain different races of yeast yields better results than the use of either of them separately.

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